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REPORT

ON

A PRELIMINARY SURVEY

FOR

THE WATER SUPPLY

OF THE

CITY OF MONTREAL.

BY

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ENGINEER.

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Queen's University at Kingston

PRELIMINARY REPORT.

To E. Atwater, Esquire,

Chairman, Water Committee, Corporation of Montreal.

Sir,

In compliance with your instructions of 15th June last, I have made the necessary Survey for ascertaining the practicability of bringing water from the head of the Lachine Rapids, for the purpose of affording—not only an ample supply for consumption, but also sufficient power to force this supply into the different wards of the City, and into suitable Reservoirs.

My instructions were directed towards this particular plan of supply—but as I have been requested to compare it with other proposed or possible ones, I will first allude to the subject of water supplies in general, and to the particular facilities available to Montreal, for securing an abundance of this invaluable element.

Three modes of water supply are usually open to the Engineer, the selection from which is to be determined by the positions of the city or town to be supplied.

The first is by "Gravitation,"—where water can be obtained at a high level, and be brought into the City, in such manner as to supply its highest districts by its gravity alone. This is undoubtedly the best method, where sufficient head and volume of water are attainable at a justifiable outlay.

The second mode is,—by pumping from a river, springs, or wells, into reservoirs of sufficient height,—or without reservoirs, directly into consumption by the aid of stand pipes.

The third method—where no water presents itself within reach of the surface,—is by means of Artesian

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Wells, sunk until a subterraneous vein of water is intercepted and conducted to the surface, and if necessary, pumped into reservoirs or into the service pipes.

From the first mode of supply, the City of Montreal is precluded, except at a cost not justified by the circumstances. Situated upon an island, and surrounded by a plain but slightly elevated above tide water, no sufficient supply presents itself, at a high level, nearer than the mountains beyond New Glasgow, whose rain shed is into the Ottawa River. A sufficiently abundant and elevated supply could probably be obtained from this quarter by an aqueduct, as long and expensive as that of the Croton, approaching the City by the route of Isle Jesus, where no navigable channels intervene.

The necessary passage of the St. Lawrence forbids the idea of a supply from the south side of this river.

The geological features and rocky substrata underlying the City, hold out no hope of obtaining a supply, by means of Artesian Wells—even if other circumstances were to render such a course desirable.

But while you are by position restricted to the second mode of supply—Pumping—you have the satisfaction of knowing that this presents itself under the most favorable conditions. One of the largest and purest rivers in the world flows at the very feet of your City—affording not only an illimitable supply for consumption, but the cheapest power for elevating this supply into the highest parts of the City.

Unless a "Gravitation" supply be ample for all future wants, and sufficiently elevated to supply every house, it is more or less limited in its value. In most cities supplied by this means, the elevation is insufficient, either from the want of head pressure, or of ground high enough to place a reservoir upon; moreover, inasmuch as a fixed scale of dimensions must be assumed, there is no opportunity for enlargement with the increase of population,—the City must therefore, sooner or later, be put upon a short allowance, or else, a total reconstruction

of the works becomes necessary. But, in the case of Montreal, the fountain head both for power and supply being inexhaustible, the works may be periodically enlarged by successive generations to meet their increasing wants, so long as the St. Lawrence flows toward the sea.

With respect to the scarcely less important question of delivery, the mountainous characteristics of Montreal not only afford peculiar advantages, by admitting of high reservoirs at the same cost as lower ones, but the mechanical mode of elevation to be employed will enable you to maintain reservoirs of different dimensions, if necessary, at different elevations; and from time to time, as the sides of the mountain become occupied with public or private buildings, the never ceasing power of the St. Lawrence will be available to afford to the remotest of these, bountiful supplies of this inestimable blessing.

In comparing the plan proposed for supplying the City, with other modifications of the same principal, I do not propose to institute a comparison between steam and water power, as I presume the experience of the Corporation is conclusive on this head. I would, however, observe first, that whatever objections there may be on the score of expense to the employment of steam, these are heightened in the present case by the necessity for importing fuel, and its consequent high price here. The consideration which, in my judgment, is conclusive upon this head, and which, in fact, is the leading principle of the proposed plan of supply is, that if it be necessary to go to the head of Lachine Rapids, to obtain a supply sufficiently pure for consumption, a slightly increased expenditure, while securing this supply, will bring in along with it, sufficient power to deliver that supply to our highest streets and tenements. That it will be necessary to go to these rapids for a pure and certain supply, when dealing with so grave and permanent a question as that of providing an important city, for all time, with one of the most indispensible elements to the health and comfort of its citizens,—I hope to show.

It has been proposed to employ a water power from the Lachine Canal, and by means of it to force water from some contiguous part of the river into the Town; and I believe the idea has been entertained of taking the supply for consumption, as well as the water power, from the Canal.

The Lachine Canal is fed from the St. Lawrence through a basin cut off from the river by means of a long water-tight pier—which basin receives and retains the drainage from the Village of Lachine, and also that of the constant succession of steamers and other craft which arrive and depart during the season of navigation. This canal is the common cess-pool for the offal of boats of every description passing through it. The soil, a clayey one, is constantly disturbed by the agitation produced by emptying the locks, or by the screws and paddles of passing steamers,—and, lastly, it lacks that uniform and vigorous current by means of which water relieves itself from all temporary impurities. The canal water might be filtered before going into consumption, could the popular repugnance to its antecedents be overcome, but there is, I conceive, a fatal objection to any scheme based upon employment of the facilities afforded by the Canal in any shape. In no matter should a city be more thoroughly independent than in its water supply; and it would be a sufficient reason for the City to discard all connection with the Canal, (in this matter,) from the simple fact that it can have no control over it.

It is the usual practice of the Board of Works to take the water out of the Canal, for purposes of repair, for a week or more in March or April; and when necessary it has been taken out for a month, in August—the business in this month being lightest—although this is precisely the period when the water consumption of the City would be heaviest. Besides this, the supply would be liable to interruption, without previous warning, at any moment,—from accident,—a breach in the embankment, or a gate knocked out by a steamer. Lastly, the Government lease

only the surplus water, and when increasing trade multiplies the demand for lockages, all water tenants must give way to the navigation; so that it is very doubtful whether a lease could now be made at any one point, for the large amount of water power which it would be incumbent upon the City to secure.

But if, by employing large storing reservoirs, the uncertain power of the Canal, could be risked—and assuming that canal water, filtered or otherwise, would be proscribed for consumption, it is necessary to determine the point on the St. Lawrence, from which the supply is to be drawn; and which point must be within reach of a water power from the Canal—that is, at some place on the river bank above the canal entrance. The breadth of the shoal, extending out above and below Point St. Charles, is about half a mile, and a suction pipe of this length secured against the "grounding" and "grinding" of the ice, would be indispensible, in order to attain a point of sufficient purity, and depth enough to prevent its being choked by "anchor" or grounded "bordage" ice. The whole of this portion of the river is so shallow that there would always be risk of having the supply suddenly cut off by the action of the ice.

With respect to the purity of the water to be obtained above the Harbor, it may be stated that if any objections have been urged against the present point for taking water from the river, on account of its proximity to the sewage discharge of the City, these objections are by no means wholly removed by the above proposed new point of departure. At present the river front, between the mills and Point St. Charles, has few living occupants—but the drainage from the burial trenches of the victims of 1847, may be considered reason for condemning any point below the Emigrant Sheds. But we must look forward to the growth of the City south of the Canal, when the whole river bank opposite Nuns' Island will be peopled, and the sewage discharge become objectionable. The extreme shallowness of the water is the

principal objection to any point of supply, from the immediate bank of the St. Lawrence, between Montreal Harbor and the head of the Lachine Rapids. In summer, the water exposed in shallow pools to the sun becomes heated, and from want of volume can be rendered impure, notwithstanding its current. In winter not only will the irregular lodging of islands of ice render any point of supply uncertain, but the increased current along shore, caused by the ice dams on the shoals, disturbs the bed and banks so as to render the water positively turbid.

If it be desirable to obtain water from the river in the immediate neighborhood of the City—to be elevated either by steam, or by water power from the Canal, (if the latter can be applied,)—it will be decidedly better to take it from the channel opposite St. Helens, than from any point above—making the suction pipe of sufficient length to extend beyond, and below the influence of the sewage discharge from the City.

For the foregoing reasons, I am of opinion that the plan of going to the head of the Lachine Rapids for water is the best one, under all the circumstances, which can be adopted for the supply of Montreal. It remains only to allude to its financial aspect.

It may be argued, that although the annual expenditure after completion will be much less, for the same quantity delivered, than the annual expense for a supply by the present mode, (steam-pumping,) yet if the interest upon the capital to be invested in the new enterprise, exceeds, when added to the cost of management, the whole annual expenditure for pumping the same supply, by steam—the propriety of the new plan may be doubted. The determination of this depends upon the quantity to be supplied, and the height to which it is to be elevated: for while, with steam power, the cost increases almost in proportion to the quantity and height raised, this is not the case with water power, with which the most abundant supply may be provided at almost the same cost as the most limited one. And herein lies the advan-

tage of a plan where the cost is one of preliminary outlay chiefly—as compared with one, in which every increased facility is burdened by a corresponding increase of cost. If the quantity required were fixed, and not to be increased,—and if the cost of procuring it were to be a permanent burden upon the present generation, there would be good reasons why a known annual cost, in steam power should be preferred to the investment of a large sum, and payment of interest thereon, in order to secure ultimate economy of management. It is, however, fairly to be assumed that such an enterprise as the water supply of a city, will be a self-sustaining one;—and that, therefore, the burden of any investment, will be but temporary. And as the consumption will increase—not merely by the natural growth of the City, but with the facilities for extending the supply—it is evident that nothing but absolute poverty can justify the continued use of steam, where another power is within reach, which promises not only ultimate economy, but (what is far more important) an extension of the consumption, and all the advantages which flow from it—which result will never take place if the use of steam be persisted in.

The uses of water are not confined to domestic purposes only; its abundance and cheapness give rise to manufactures, and thus become sources of immediate profit to the community. Secondly, by an overflowing amount and a sufficient head pressure on every street, the extinction of fires becomes certain and speedy; and this, by reducing insurance and giving increased security, attracts immigration and capital. Thirdly, with the intense heat of our summers, and the inordinate amount of dust generated, water should be used most unsparingly not only for the comfort of the citizens but as a preservative of property. The damage done by dust to goods and furniture, at places and in seasons where and when doors and windows must be left open,—cannot be ascertained, but, could it be, it would be found to cover a large proportion of the interest upon the cost

of works which would obviate the evil. Fourthly, in the supply of fountains—in parks, public gardens, and pleasure grounds, abundance of water must be considered not merely as a luxury, and as purifying the air,—but as possessing a positive commercial value. Every object of interest and beauty about a city is an additional attraction to the tourist, and the seekers of pleasure or amusement—always the wealthier classes of society. Those who know how much our steamers, hotels, and carters, are dependent upon the annual stream of "pleasure travel," can best estimate the amount of money left by this class, and the relief thus afforded to the whole community. Indeed, if the positive paying character of the speculation were fully appreciated, much greater attention would be given to embellishing, by a sound taste and a little money, the many natural beauties possessed by Montreal.

DESCRIPTION OF THE PLAN.

It is proposed to take water out of the River St. Lawrence at a point about one mile above the head of the Lachine Rapids. The river here flows deep and strong within a few yards of the shore, and ranges but little between its extreme high and low water marks. At the point where the Aqueduct would commence, the level of the river is thirty-seven feet above the summer level of Montreal Harbor.

The water is to be conducted in an open channel, four and three quarter miles in length, to the Lachine Canal at Gregory's. Here the wheels and pumps would be placed,—the waste water being discharged into the St. Pierre River, which has a fall of about 12 feet between this point and the St. Lawrence,—but being narrow and crooked, some clearing out and enlargement of its channel will be required. On account of the winter elevation of the St. Lawrence, it is proposed to keep the "tail race" from the water wheels, at least twenty feet above low water level of Montreal Harbor; this will leave a

head and fall of at least sixteen feet at the pumps,—about one foot of fall being assigned to create a proper current in the Aqueduct.

From the Pumps at Gregory's, the water is to be forced through an iron main, 30 inches in diameter, laid under the Canal, turnpike, railway, and all the public streets, into a reservoir, at about the elevation of the residence of the Hon. Mr. Justice Smith, being about two hundred feet above the level of Montreal Harbor.

Having presented the general features of the plan, I proceed more particularly to the different heads.

The Aqueduct.—The dimensions proposed for the channel to conduct the water from the St. Lawence above the Lachine Rapids, to the water wheels at Gregory's, are—twenty feet width on bottom, forty feet wide at the water surface, and eight feet depth of water. The wetted perimeter of the canal is to be faced with stone and gravel, and the profile of the bottom to have an inclination of about 2½ inches per mile. The capacity ensured by the above specifications is greater than would be required for passing the requisite quantity required by the wheels and pumps, but a considerable margin is provided to guard against a diminished flow in winter, when the ice will occupy a large per centage of the sectional area; and also to cover all losses from evaporation, leakage and filtration. The cost of an open channel does not increase proportionally with the sectional area; and, as great additional capacity is to be attained at slight increase of first cost, it is better to provide against any necessity for early enlargement,—as well as against the filling up of the channel by gradual depositions. Lastly, the volume of water thus secured is too great to be influenced by any ordinary impurities to which it will be exposed.

As some objections have been urged to an open conduit, I will mention them here.

The distinguishing feature of the present plan, as compared with Aqueducts generally, is, that it is proposed

to conduct not only the quantity required for the consumption, but the very much larger volume which is needed to supply two hundred horse power under the given head. Now, the great advantage possessed by an open canal over every enclosed form of conduit, is, that it will deliver the greatest quantity with the least loss of head—a consideration of the first importance when a water power is in question. If iron mains or brick culverts of reasonable number or dimensions be substituted, nearly the whole available head and fall would be required to overcome the friction, and the water would be delivered at Gregory's robbed of all its value as a moving power. Brick culverts would be a very much cheaper form of conduit than iron pipes, for such a volume, but the full duty from these could not be exacted without the risk of their being blown up, as it would be necessary to place the entrance mouth of these culverts below the level of the ice, which arrangement would expose them to a considerable pressure at high water, particularly, if (as they should have) an efficient fall per mile be given to them. Iron mains, therefore, would be the safest,—but these should be of the largest possible dimensions to guard against friction, and possibly the effects of "anchor" ice, which, at several points on the St. Lawrence is known to float into the shallow mill races, or flumes, and permanently resist all attempts to drive the machinery. To pass the same volume of water as would flow through the open Aqueduct proposed, would require more than a dozen iron mains of the largest size, 5 feet diameter each, laid with an inclination of double the rate per mile of that of the open channel, while the cost of any one of these pipes would be at least double that of excavating the Aqueduct, and as much as the whole cost of the latter, including land damages, masonry, bridging, and lining with stone.

The Lachine Canal and water power thereon, are evidence of the perfect practicability of maintaining a full supply of water, by an open channel, during the severest winters.

The only objection, therefore, which can be urged against the open Aqueduct, is, that the water will be exposed to impurities. We have alluded to the utter incapacity of pipes to convey a water power such as is required; if therefore the objection to the open canal, on the ground of its exposure, be sustained, it will obviously be sound policy to excavate an aqueduct for the water power, and lay a pipe within it for the water supply, as nearly the whole fall could be given to the pipe —which to pass 5,000,000 galls. in 24 hours, would require a diameter over 30 inches and a fall of 10 feet in the whole distance. The cost of this pipe would be about the same as that of the excavated Aqueduct.

The objections to an open canal, are reduced in the present case, by its secluded position. In the whole length of nearly five miles, it is crossed by but two public roads, notwithstanding its proximity to the City. By fencing in the route, and passing the highways by tight bridges, any interference must not only be premeditated, but upon such a trivial scale as would render harmless such useless and unprofitable mischief.

The New River—an artificial open channel 40 miles in length, and crossed by 200 bridges, has, for 240 years, furnished the principal supply of water to London. The Canal de l'Ourcq—24 leagues long—serves the same purpose to the City of Paris. Dublin and Greenock are likewise supplied by open Aqueducts.

In the recent agitation for an improved water supply for London, two of the leading schemes proposed, contemplate open canals. The "Henly Scheme" embraces an open canal to cary 200 millions of gallons daily.

The "Maple-durham Scheme" proposes an open canal 4½ miles long, (about the same length of yours) for a part of the distance—thence, through three iron pipes of five feet diameter each.

The objections to open canals are:—

1st, Loss of water by evaporation, leakage, and filtration.

2nd, Exposure to breaches in the embankments, from long continued rains.

3rd, Exposure to impurities, either from wash and surface drainage—absorption of the earthy strata through which it passes—or from deleterious substances thrown in, ignorantly or maliciously.

In the present instance, the first objection disappears with the unlimited abundance of the fountain head; the second need not exist, inasmuch as the topography of the route admits of the whole line being "in excavation," avoiding embankments and their attendant risks.

With respect to the third—wash and surface drainage may be prevented by a thorough system of side ditches, and off-take drains, and by "sodding" the inner slope of the banks above water. By lining the sides and bottom of the Aqueduct with stone and gravel, no impurities will be absorbed—so that there only remains the single objection of exposure to impurities thrown in. The great volume of water is the best security against this remote contingency. Under any circumstances the Reservoirs and entrance to the Aqueduct cannot be covered, so that inspection and legislative aid must be relied on to protect the works from malicious injury.

On the other hand—the advantages of the open canal are:—

1st, It is much cheaper than any other conduit of the same capacity.

2nd, Water flowing freely in open channels, exposed to light and air, not only frees itself from impurities it may hold in suspension—but diminishes its hardness.

3rd, In this climate, for one-third of the year at least, an open aqueduct will be protected by a covering of ice, rendering it as secure as a covered one.

4th, It is susceptible of future enlargement.

From the position of this Aqueduct, and the highly favorable nature of the ground, it may be considered a practical extension of a branch of the St. Lawrence to

the borders of the City at Gregory's,—where the water can be delivered in nearly as pure a state as when it leaves the river. The fears of injury to the water are rather imaginary than real, and may be disposed of altogether by the construction of large subsiding reservoirs at the pumps—for which purpose the surrounding ground is highly favorable. Many cities are supplied by water collected on gathering grounds under cultivation—by means of catch-water drains leading into storage reservoirs, where the water is purified by subsidence.

The Survey was directed principally to the plan of bringing the open Aqueduct as near the City as practicable—or until it would be intercepted by the Lachine Canal at Gregory's—the nearest point where a discharge for the water from the wheels could be readily secured. It is very desirable to shorten as much as possible the length of the "rising main" through which the water is to be forced—as this will be a saving in power, and a diminution of risk—particularly when that end of the main which is subject to the heaviest pressure is shortened. It would be more convenient to have the pumps and reservoirs at Gregory's than nearer the Rapids, as they would then be under the influence of the Police and City authorities:—also, if the Aqueduct be properly constructed, what may be termed the artificial works, requiring close attention, will hardly commence until we reach Gregory's.

A modification of this plan is, however, practicable—which possesses some advantages.

By placing the pumps near the Telegraph Mast, at the foot of the Lachine Rapids—the length of the open canal would be shortened nearly three miles—for which a corresponding length of rising main would be substituted. By this arrangement the cost of the Aqueduct, land damages, and bridges, would be reduced: and by placing the wheels nearer the river, the cost of the "tail race" would be diminished. If the water for consumption can be obtained from the river sufficiently clear at all seasons of the year to go into the pumps—an important reduction

in the cost of the Aqueduct and protection of it from trespass will be effected—because in this case the canal will be cut for the water power only, and the expense of lining be evaded. This would also remove any objections on the score of exposure—which in this case is altogether avoided. There is, however, a question of back water on the wheels, from the lodging of ice on the shoals at the foot of the rapids—to be first determined, and it is also doubtful whether the supply can be taken from the river at this point. The adjoining ground is not so favorable for subsiding reservoirs as at Gregory's—and, lastly, the increased power required, and the increased risk of nearly three miles additional pipe under the highest pressure, are set off against the greater economy and reduced exposure of this plan.

The selection between these two sites for the pumps will be determined by more extended surveys and estimates, and particularly by the relative land damages upon the two routes—and the question of right of way across the Aqueduct.

The Reservoir.—Next to an abundant and constant supply of water, the most important consideration is the height to which it can, when required, be delivered, and the amount of head pressure which can be obtained. Irrespective of the necessity for supplying the highest dwellings or the upper stories of lofty buildings, the greater the pressure, within the limits of the strength of the service pipes, the better will be the distribution; and greater security against the ravages of fire is attained. In other cities, as New York and Boston, distributing reservoirs have been constructed at enormous cost, above the surface of the highest attainable ground; but here the proximity of the Mountain and its successive terraces, enable us to select any required height, at nearly the same cost, for the construction of our reservoir. A little more power and a little more pipe, provided for in the first outlay, and a high service is as easily secured as a low one.

The most ordinary pipes will bear a pressure with

safety of 300 feet head of water. The pipes at present laid in the City, are all under 12 inches diameter, and capable of bearing a pressure of 450 feet and upwards;—the strength of metal in pipes of these dimensions being determined, not by the water pressure they are to sustain, but by what is requisite to make a good casting. They are in fact subject to strains from their position in the streets, which call for greater strength than what is required to resist the water pressure.

With an efficient head pressure great economy in the distribution is secured—a smaller sub-main or service pipe will supply the place of a larger one with a lower head. The "high service" remedies the common evil of a failure in the delivery at points most distant from the reservoir, and in the upper stories of buildings which may have a plentiful supply in the cellar. With a "low service,"—while the City is drawing,—the water is not allowed time to ascend to the height due to the reservoir head—except at night. The remedies for this are—pipes of extravagant dimensions, or a reservoir sufficiently elevated above the point of delivery to feed the service pipes faster than the consumption, and send on the surplus to the higher, or the more distant points.

But it is as a safe-guard against fire that the high service is to be chiefly commended. Too many towns are restricted to—or are content with,—a pressure sufficient only to fill the engine tanks—relying on manual labor to throw the water on the flames. This need not be the case with Montreal—for here the merchant may have his private hose on every floor of his warehouse, and by simply turning a cock play upon a fire as soon as discovered.

In the important process of cleansing the streets the benefits of a heavy pressure are apparent, enabling you to scour instead of simply wetting them; and the greater the pressure the greater number of square yards can be commanded from one plug.

Lastly,—The pipes in upper stories should be con-

stantly full; if alternately wet and dry from insufficient head, air is admitted and oxidation takes place, imparting deleterious properties to the water, injurious to health and destructive to the pipes.

As it is not practicable to place the pumps nearer the reservoir than Gregory's, (on account of the intervention of the Lachine Canal,) it was desirable to ascertain the nearest point to this possessing sufficient altitude, and suitable for a reservoir. A line was therefore run to the mountain, near the residence of the Hon. John Young. The distance to this point would be about one and a half miles, but as a reservoir here would be too far from the City it was considered preferable to select a site near the M'Tavish property—this quarter affording ground of the required elevation nearer to the commercial heart of the City than any other point. The rising main is lengthened by this arrangement but the whole length of influent and effluent pipe is diminished, and—what is more important—the great body of the water in this main and in the reservoir is laid nearer to its required destination.

The Pumps.—It is proposed to erect two breast wheels, constructed wholly of iron, with ventilated buckets, having a diameter of about 20 feet and not less than 22 feet length of bucket. The power is to be taken off the inside of the periphery of the wheel upon the loaded side only. The power of each of these wheels to be about one hundred horses. The breast wheel, for falls under 20 feet, possesses several advantages, particularly for the slow and regular motion required for driving the pumps. By admitting of a diameter greater than the fall, it receives and discharges the water to better advantage,—works longer in and is less retarded by back water than the overshot wheel.

The wheels and "plunger" pumps will be placed within a substantial building, fire and frost proof: the bulk heads, foundations, tail races, &c., to be constructed upon the most substantial and improved plans.

THE RISING MAIN.—This should have as large a diameter as can be afforded, in order to diminish the friction and strain on the pumps and pipe itself, and lessen the power required. From the unavoidable distance of the pumps from the reservoir and centre of the City, it is desirable that the main supply pipe should have the largest capacity possible, and thus plant a good body of water as near the centre of distribution as practicable. This is assuming as probable—that as the "rising main" traverses the City on its way to the reservoir, the supply will be taken from it at intermediate points.

The track of the "rising main" may enter St. Catherine Street either by Mountain Street, or ascend the Cote beyond the Baptist College, and come down St. Catherine Street to the Protestant Orphan Asylum,—where a branch would turn up to the Reservoir, and the main may continue on through this street to the north-eastern quarter of the City. Taken in respect both to elevation and position, the line of St. Catherine Street traverses the City in a central position—planting a large body of water everywhere within reach of the smaller pipes already laid.

QUANTITY OF WATER.

The scale of works contemplated by this survey,—as assented to at the commencement,—was for a daily supply of 5,000,000 imperial gallons, and for a reservoir at an elevation of two hundred feet above Montreal Harbour —being about 140 feet above the higher points of Notre Dame Street. Thirty gallons per head, is the usual provision, with proper allowances for the increase of population—but recent experience has shewn the average consumption in New York and Boston to have risen as high as fifty to sixty gallons per head. The above amount provides about 40 gallons per head for a population double that of the City at present, and considering the facilities for extending it under the proposed plan, is, I consider an ample provision. The dimensions of the

Aqueduct are sufficient to conduct water enough in summer when the flow is unimpeded by ice, for an effective power, on breast wheels, of three hundred horses; and as this is the season when the greatest supply is required, the erection of an additional wheel and an increase in the speed of the pumps will enable you to extend the supply as required. With you, therefore, it may prove the wiser policy to provide for that *waste* of water so much complained of in New York and Boston —rather than to rely upon your future ability to check or prevent it.

The Estimate.

Since the great fire a natural anxiety has been manifested to obtain the results of this examination at the earliest possible period. The limited nature of the appropriation did not admit of the preparation of detailed plans and estimates of the different structures required. It was therefore understood that the object of the present survey was principally to ascertain the practicability of the proposed plan, and the approximate cost of the same, in order that it might be submitted—when if the scheme were rejected, no more time or money would be wasted upon an unsuitable project. The importance, however, of the subject, and the strong probability that the present plan would be recognized as the only efficient mode of supply—rendered it desirable that the whole available ground should be examined, and all the main features of the project weighed before an estimate, which is to be the basis of future operations, could with safety be offered. The intermediate country has been topographically surveyed—two lines have been located, and the nature of the excavation ascertained by test-pits and borings. The survey, therefore, is only wanting in the detailed plans and estimates of the different mechanical structures required:—but ample provision has been made for these under any variations of the plan which experience in the development of the works may suggest.

One important item in the estimate is the rising main —which is single and 30″ diameter. As a precautionary measure, two pipes of a smaller size are often substituted for the larger one—in case of accident or repairs to one. One large pipe is however cheaper and better than two smaller ones of equal area; and, from the great length of this pipe I do not consider the remote risk would justify the expense of a double one. Properly constructed, there should be no more necessity for the duplicate system in this pipe than in other parts of the work. The 30 inch pipe, however, is provided to afford the full supply of 5,000,000 gallons daily. As this quantity may not be required for some time,—a smaller pipe may now be laid, and an additional one at a future date:—the only point where a double pipe may be desirable, would be in the passage under the Canal, where the pipe would be inaccessible during the season of navigation.

I esitmate the cost of the aqueduct, wheels and pumps, rising main, reservoirs, with the land purchase, masonry, bridges, enclosures, &c.,—all the work to be done in the most substantial and permanent manner,—at the sum of ONE HUNDRED AND FIFTY THOUSAND POUNDS.

Estimate of Revenue.

The population of Montreal being taken at 60,000—the number of "water tenants," according to the experience of other cities, should be about 8000. The average charge per tenant in New York and Boston is about $10 per annum, and in the city of Philadelphia about $5. At the Philadelphia rate, the present population of Montreal should give a gross income for water rates of £10,000 per annum.

The actual income from the present Water Works of this City is as follows:—

1064 annual tenants,.....	£5345	8	10	
Sale at water taps (2d. per puncheon),	1090	14	3	
Special tenants,.....	47	10	0	
				£6483 8 1

The foregoing is the revenue only. The amount paid for water by the City is much larger. In addition to the

£1090—paid the City for some 130,000 puncheons at the water taps—the consumers pay for cartage of the same (at 7d. per puncheon) the sum of £3790. What amount of water is carted from the river is not known—but here we have £10,270 paid for water supplied by the present Water Works. It is probable that the amount paid for cartage of water from the river during the winter, would increase the gross annual payment for water by the City, exclusive of wells, &c., to some £11,000 or £12,000.

The inefficiency of the present supply needs no demonstration. The capacity of both engines, working constantly, is reported at 1,000,000 gallons in 24 hours or about 16 gallons per head of the population; what quantity is furnished, on the average throughout the year, cannot be ascertained,—probably not ten gallons a head per diem. This inferior supply costs the Water Works Department about £2500 per annum. Assuming that one million of gallons were raised daily, this would be the extravagant price of £7 per million gallons—and it most probably is £10 per million gallons. The cost of raising one million gallons at the Fairmount Works, Philadelphia, in 1850, was 8s. 0½d. only!

If the new works were constructed, five times the quantity of water at present supplied would be furnished to eight times as many tenants, at a cost to each of about one-third the present charge. The present population of the City, at the Philadelphia water rates, (the lowest in America,) should pay an annual revenue of £10,000—a sum nearly sufficient to cover the interest of the new outlay and the annual charges of management, &c., giving the City water for fires, street watering, and fountains, free;—and as the population increases the rates may be reduced, or a sinking fund be formed of the surplus, for extension of the works or extinction of the debt.

These favorable prospects are due to the cheapness at which an abundant supply can be obtained at Montreal, as compared with some other cities. The Croton Works cost the citizens of New York about £10 per head—the

Boston works cost that city about £8 per head. Equally efficient works here can be had for £2 10s. per head, exclusive of the cost of distribution.

Nor should the other advantages of a full supply and of the new plan be overlooked.

The extension of manufactories—particularly those requiring a supply of pure water—would not only enrich the City, but enlarge the water rates. The Fairmount Works number in their water tenants no less than 138 steam engines, and several hundred manufactories of every description: some of these engines pay £50 per annum for water, and one sugar refiner pays $750 annual water rate.

The diminution of the annual cost of supply on the new plan, is forcibly shewn by the following comparative statement of the cost of water power and steam power in the city of Philadelphia.

The total expense of running the eight wheels and pumps at Fairmount in 1850, was as follows:

"For wages of workmen, tallow, oil, packing yarn, and fuel for heating
" the mill house,....$2594,91 per annum, or $7,10$\frac{9}{10}$ per diem.
"For repairs to wheels
" and pumps, during
" the year,.....216,27 59$\frac{3}{10}$

$2811,18 per annum, $7,70 per diem.
£702 15 11 do £1 18 6 do

" For which sum an average of 4,785,338 ale gallons per day were
" pumped by the eight wheels and pumps, equal to a cost of about $1,61
" per million gallons raised per day.
" The cost of pumping by steam power at the Spring Garden and Northern
" Liberties Works in 1850, was as follows:—
" For coal, wages of workmen,
" tallow, oil, yarn, &c.....$16,644 per annum—$45,60 per diem.
" Repairs to engine and pumps,
" during the year.....5,127,46 do 15,06 do

$21,771,46 $60,66
£5442 17 3$\frac{1}{2}$ do £15 3 3$\frac{1}{2}$ per diem.

" For this sum an average of 3,231,254 gallons per day, were pumped by
" three engines and pumps,—about $18,77 per million gallons per day."

Thus the cost per million gallons by steam was $18,77.

Do. do do do water, do 1,61,

or, in other words, four and three-quarter millions of gallons were supplied at a daily cost of thirty-eight shillings.

by water power, while three and a quarter millions pumped by steam cost 303s. daily: and the Fairmount Works, at a cost of £702 per annum, furnished one-third more water than the steam works, at a cost of £5442 per annum.

I am informed by the manager of one of the principal insurance offices in this City, that, previous to the great fire, the average amount of premiums paid at all the offices on property insured within the City might be estimated at about £25,000: and that since the fire the rates have been increased upwards of fifty per cent.:—so that the premiums on the same amount of risks would now amount to about £40,000 per annum. The same gentleman is of opinion that an efficient supply of water would have reduced the old rates twenty per cent.; or that instead of £25,000, the amount of the premiums before the fire would have been reduced to £20,000. From this it may be inferred that the City is now paying a penalty of £20,000 per annum in extra insurance from the want of proper means for extinguishing fires. No doubt part of the present increased rates of insurance are levied to make up losses—and some part of it may have reference to the fire department, but it does not appear unreasonable to assume that at least £10,000 per annum would be saved in this single item of insurance, if the City were in possession of an ample supply of water. This sum would pay the interest on the cost of the works and is therefore all that need be claimed under this head: but, the actual money value of the additional security obtained through an abundant supply of water would be far higher, because it will embrace the reduced risk upon all the property in the City, whether insured by the Companies or by the owners.

But arguments are unnecessary to prove the great economy of a water supply on an efficient scale. With the experience of the past year no rates would appear safe for insurance companies—and with the recurrence of such calamities insurance must become impracticable—or

unnecessary. It is argument enough for the expenditure of £150,000 for preservation from fire alone (setting aside the other advantages of abundance of water) that we have seen property to five times that amount utterly annihilated in a few hours, and that a repetition of such a catastrophe is by no means impossible.

I have the honor to be,

Sir,

Your obedient Servant,

THOS. C. KEEFER.

OBSERVATIONS

ON

Mr. Keefer's Report on a Preliminary Survey

FOR THE

WATER SUPPLY OF THE CITY OF MONTREAL,

BY THOMAS WICKSTEED, C. E.

40 Coleman Street,

London, 19*th January*, 1853.

Although unacquainted with the gentleman who has written the Report submitted to me for consideration, it is evidently the Report of an intelligent Engineer.

After a careful perusal and consideration of this Report, I am enabled to make some observations which I trust may prove of use, although it is necessary that I should preface my remarks with saying that without much more information than is contained in that Report, (and which would not *necessarily* be contained in a *preliminary* report,) I cannot give an opinion such as the importance of the subject, and the magnitude of the proposed outlay demands, and I should be very sorry if a want of this necessary information should lead me to express any erroneous opinions upon a Report which I consider in many respects as very valuable.

I agree with the opinions expressed in the Report upon the costly Aqueducts of New York and Boston, which, however grand they may be considered as national undertakings, will not bear examination as commercial ones; with respect to the latter place, my advice was asked for by those gentlemen who objected to so wasteful and extravagant an outlay, but it was then too late; the ambition to rival New York having taken too strong a hold on the minds of those who had the determining of the matter confided to them.

From ignorance of the locality, I must, at present, assume that it is necessary to go to a *distance* from the City to obtain an abundant supply of pure water, although the fact given in the report, that "one of the largest and purest rivers in the world flows *at the feet of your City*," would have compelled *me* to have given the subject of steam power, (notwithstanding the high price of fuel,) very grave consideration before abandoning that mode of supply, and recommending so large an outlay as that proposed to be made for the purpose of bringing water from a distance.

That the question of steam power is not one to be dismissed lightly, will appear evident after considering the following facts: In projecting new works, it will be admitted that the only prudent course to be pursued in endeavouring to arrive at a sound conclusion as to which of various modes for effecting the object is best to be adopted, that a comparison should be made with the *best* modes, and not, as it appears to me has been done in the report before me, with *old* works, where the machinery used is proved to be out of date by the extraordinary cost required to work it, for it appears that the expense for coals, wages, workmen, tallow, oil, yarn, &c., and repairs to engine and pumps for raising 3,231,254 gallons per diem at the Spring Garden and Northern Liberties Works, amounted, in 1850, to £5,443, while the cost of raising the same quantity of water by the "Wicksteed Engine," at the East London Water Works, Old Ford, in 1849, which you have, I believe, seen at work, was £890; but supposing the price of coals at Montreal to be twice that of those in London, the cost would then be £1100 only, or a little more than one-fifth of that of raising it in Montreal in the year 1850; the difference between the two steam works is, that the first is old and out of date, while the latter although new has had its merits proved by a practical experience of more than ten years. It certainly is only fair in making a comparison of the cost of *new* works to make it with the best known; again, when

I state that to raise water at Old Ford in 1829, the cost was above 56s. per million gallons, while in 1849 it was not more than 15s. it will show what improvements were made in the course of twenty years, and there is no reason to suppose that farther improvements will not be made during the next twenty years, and that Water Works Companies will avail themselves of such improvements, but the interest upon a very large capital is a constant drag which no improvemeot will reduce, or relieve you from.

There can be no question that when you have ground sufficiently elevated in the neighbourhood of a town to be supplied with water, that the use of a summit Reservoir is the best and most economical mode of distributing the supply.

As respects the question of the contamination of the water in consequence of the sewage being discharged into the stream, it has hitherto been a very great difficulty in the way of economical water supply, forcing the water companies in various towns to go a distance up the stream to avoid the nuisance, but I am happy to be able to state that this difficulty will be removed before long. I have for some months diverted a considerable portion of the sewage water passing down one of the largest sewers in the town of Leicester, and after separating all the noxious ingredients, *dissolved* as well as suspended in it, in the form of marketable manure, have returned the water into the river, in a state of as great purity as the water in the upper portions of the river before it is contaminated.

A London Company, in which I am interested, have entered into a contract for a period of thirty years with the Town Council of Leicester, to separate the noxious ingredients from *all* the sewage water of the town, and discharge the water into the river in a pure and uncontaminated state, and as the works to effect this desirable object are now in course of construction, during the next twelve months, the fact will be made manifest in a town

of the same population as Montreal, and as this will be on a sufficiently large scale, it will, I trust, set this moot question at rest. I have made these latter observations for the purpose of showing that if the question of sewage water flowing into the River at Montreal has been considered one of such importance as chiefly to induce the expenditure of a large sum of money to bring water from a distance, it is one, that *under existing circumstances*, should be dismissed without further consideration.

The plan proposed to supply Montreal with water appears to be as follows:

To make a Canal or Aqueduct, 20 feet wide at bottom, 40 feet wide on the water surface, and 8 feet depth of water, with a fall of 2½ inches in a mile; this is to extend from a point on the river St. Lawrence, about one mile above the head of the Lachine Rapids, to the Lachine Canal at Gregory's, a distance 4¾ miles,—here it is proposed to erect two breast water wheels, 22 feet wide each, with an available fall of 16 feet, which are estimated at 100 horses power each; the dimensions of the Canal, however, at the given fall per mile, are such as will enable it to bring down water sufficient at this fall to produce an effective power of *above* 300 horses, and supposing that the objections to an open Canal for bringing water for consumption cannot be overcome, it is proposed in addition to lay a 30 inch pipe in the open canal to supply 5,000,000 gallons of water for 24 hours consumption; the proposed fall for this pipe in a distance of 4¾ miles is 10 feet.

I should observe, however, that to deliver 5,000,000 gallons in the 24 hours, the fall must either be increased beyond the 10 feet, or the pipe must be 35 inches instead of 30 inches diameter.

From the pumps at Gregory's, it is proposed to have a rising main to a Reservoir situated on "the Mountain," at an elevation of about 200 feet above the pumps. An alternative plan, however, is proposed, to which, with my present information, I give the preference, and I think

deserves further consideration before it is abandoned, as the arguments advanced for it appear to me more forcible than those against it.

The plan is to place the pumps near the Telegraph mast at the foot of the Lachine rapids, and for the 3 miles between that and Gregory's to lay a main instead of cutting an open Canal—the power to overcome the friction in this main, supposing it to be 30 inches diameter, and capable of delivering 5,000,000 gallons in 24 hours, will be equal to 14 horses. This forms so small a proportion of the whole power required, that even if steam power were used, the objection would be by no means formidable, but with water power it would be still less so.

To raise 5,000,000 of gallons, which is the amount proposed to be given to double the present population of Montreal, to a Reservoir elevated 200 feet above the pumps, the water flowing through a 30 inch main 4½ miles in length, it will require a power of about 230 horses, while to raise *half* the quantity for the present population would, on account of the reduced friction caused by the less quantity of water, require a power of 108 horses. The cost of coals, stores, labour and repairs for the largest power would be £2100 per annum and for the least £1000 per annum.

As regards the estimate for the works, it *appears* to me very large, but without much more detailed information than I am at present possessed of, I cannot say how much it ought to the reduced, but I think it will appear evident, that as the sum proposed to the expended is so large, time should be given for grave consideration, and that the best advice should be obtained before it is determined to incur so large an expense.

More information is required—as to the quantity and quality of the water in the immediate neighbourhood of the City—as to whether it be absolutely necessary to go to a greater distance, and what the shortest distance is at which a sufficient supply could be obtained—as to the comparative advantages of steam and water power—as

to the position of the Summit Reservoir, especially as regards the question of taking the supply from the rising main between the pumps and reservoir—as to the length of streets, their levels, &c., that an estimate may be formed of the cost of pipage required; but before a professional man can give an opinion to be relied upon, he should have plans and sections of the proposed works, and a detailed estimate laid before him, and if possible, personal communication with the Engineer who will have to carry the works out.

Should it be considered desirable, I shall be happy to enter further upon the subject and give it more consideration.

THOMAS WICKSTEED,
Civil Engineer.

To the Honorable F. Hincks,
Inspector General, Canada.

REPORT OF JOHN B. JERVIS, ESQ.

To E. ATWATER, ESQUIRE,

Chairman, Water Committee, Corporation of Montreal.

SIR,

Agreeably to request, I have examined the project submitted by Mr. Keefer for supplying the City of Montreal with water. As Mr. Keefer has fully presented the plan, it will not be necessary for me to enter very particularly into explanation of the same. It contemplates the construction of a Canal or Aqueduct, by which water is to be taken from the River St. Lawrence at the head of the Lachine Rapids, and conducted about 4¾ miles to a place known as Gregory's, above the City. The proposed Canal to be of sufficient dimensions to afford the power required to elevate 5,000,000 gallons of water per day, to a Reservoir 200 feet above the level of the River St. Lawrence in the harbor of the City. The same Canal to furnish the water that is to be elevated for the use of the City. As is very proper in such works, Mr. Keefer has provided a margin of about 50 per cent. in the supply of water above the computed quantity, required for elevating 5,000,000 gallons per day, and should it be found on the completion of the works, that there is a surplus, as most probably it will, this surplus will be available for a corresponding increase, to meet the demand of any additional wants of the City at a future day. It may here be observed, that the additional size of Aqueduct to provide the above surplus, adds a comparatively small expense in the original outlay, and in view of general experience in such matters, a liberal provision in the outset has rarely been found a subject of regret. I therefore fully approve of the capacity proposed by Mr. Keefer for the work. It may be suggested to rent the surplus

power until the same may be wanted for a further supply of water for the City. On this point I would earnestly advise that no such use be made. The great importance of a full supply of good water to a large city impresses the necessity of keeping such works entirely free, when practicable, from any entanglement with other objects—and the whole project should be kept insulated and fully devoted to supplying the City with water.

The formation of the country for the proposed works, the point at which the water is taken from the river, and the secluded character of the district, are all well adapted to the object. It rarely happens that a city has advantages for the establishment of similar works equal to those enjoyed here.

The general plans submitted by Mr. Keefer are well adapted to secure the desired result. The point on the river at which it is proposed to take out the water appears well calculated to afford the purest water of the river. The Canal will pass through a district eminently excluded from causes of impurity, and so situated as to admit of guarding, by back drains, against the introduction of all land drainage into the Aqueduct. The plan of lining the bottom and sides with stone or heavy gravel, as proposed by Mr. Keefer, may not in all parts be necessary, but it will in general be beneficial in maintaining and promoting the purity of the water, and is therefore to be recommended. The works, well constructed on the plans proposed, will secure a quality of water equal to its condition when it flows from the river into the Canal, and improved, as it will be, by flowing with a quick current, near five miles through a channel of stone and gravel essentially excluded from all external causes of contamination, —a condition that will improve its quality. The plan contemplates the best mode for an open channel. It could not be improved, except by a covered Aqueduct, and it is hardly necessary to discuss this at present. The works may be put in operation, and if, as is not probable, at

some future time it should be deemed advisable to have a covered channel to carry water to the pumps, a brick conduit may be taken from some point near the head of the canal, of a size to carry to the pumps sufficient water to supply the City, having the open canal to furnish the power to drive the pumps. I mention a brick conduit because the water can be conveyed at less expense in that than in iron pipes. Such a conduit could be put down at any future time alongside of the open Canal. The strong probability is, that it will not be deemed necessary.

The estimate submitted by Mr. Keefer, is in gross £150,000 currency or $600,000. This provides for placing the water in a Distributing Reservoir, at an elevation of 200 feet above the water of the harbor. For that part of the work which includes the Aqueduct and all its appurtenances to bring the water to the pumps and on the wheels, the estimate is £76,500. For the balance, including the Pump-house, Pumps, Rising Main, and Distributing Reservoir, £73,500. If to the former be added the Pump-house and Pumps, the amount will be £90,500 currency, and will include the total expense required for wheels, pumps and building, to provide the water power to drive the pumps, and to bring the water to the pumps for elevation. In this two water wheels, each with a double set of pumps, and a building for the third wheel and pumps are provided for:—leaving for Rising Main and Distributing Reservoir, £53,500 currency. In regard to the first branch of the estimate I do not see that anything is to be added. It seems to embrace all the works required, and on a plan of permanence. The rates of estimate are liberal as compared with prices paid on the public works in this vicinity, and I do not see any ground to doubt that the work may be constructed within the cost estimated by Mr. Keefer. In regard to the second section, the provision for Distributing Reservoir is for a surface area of 90,000 superficial feet, or a little over two acres.

This will answer the purpose for equalizing the supply, and give a fair provision for any sudden demand for the extinguishment of fires. But if the ground were such as to admit an enlargement, say to double this capacity, at moderate cost, it would be advisable to have it. This, however, may be considered hereafter—as the Reservoir may be enlarged at any time. The only material item that it appears important in any respect to enlarge from the estimate is the Rising Main. This Main will be under the action of the pumps, and for that reason more exposed to injury that will require a suspension of the works to repair it, and on this account, I advise that two Mains be laid, namely, one for each set of pumps, but so connected, that the water may be forced into it, by either or both sets of pumps when the other is out of repair. Mr. Keefer has proposed a 30-inch Rising Main Two 24-inch mains will deliver, under the same head, or the same pressure, 25 per cent. more water than one 30-inch main, and will cost about forty per cent. more. If two 24-inch mains are substituted they will be able to carry a larger supply when full power is required, and one of them would be sufficient for ordinary supply when the other may be out of repair. It appears to me it will be advisable to make this change in the plan for the Rising Mains. This item if adopted will add about £10,000 to the estimate. This is the only change that I think it necessary to propose, and this is rather a matter of precaution than of absolute necessity. Mr. Keefer will no doubt approve of this, as he has intimated that such precautions might be advisable. In regard to the estimate in general, it appears to be liberal—at the same time it is extremely difficult in such works fully to anticipate all the items of expense, and I have usually been in the habit of providing a contingent allowance to meet unforeseen items that are likely to be developed in the course of construction. This, Mr. Keefer informs me, has been done in preparing his estimate, and may be sufficient.

But, though the estimate may prove entirely adequate to the cost of the work, I would still recommend that an allowance of ten per cent. be added to the general estimate. If the two 24-inch Rising Mains be adopted, the aggregate general estimate will be £160,000 currency, and if my suggestion of ten per cent. for contingencies be adopted, the total estimate will be £176,000 currency.

The population of the City, as I am informed, is about 60,000. To distribute the water, taking it from the Distributing Reservoir, would cost not far from £1 5s. or $5. for each inhabitant.

The cost of introducing the water to the Reservoir as above, would be,	£176,000	0	0
Distribution,	75,000	0	0
Total cost of water,	£251,000	0	0

Annual cost of water, namely

				An. Cost.		
Interest at 6 per cent. on £251,000	£15,060	0	0			
Annual cost for maintenance and managing works to deliver the water into Distributing Reservoir,	1,250	0	0			
				£16,310	0	0
The cost for capital in construction of the works, per inhabitant,				4	3	8
The cost of annual charges, including interest on capital and maintenance of all works except repairs of distributing Pipes, (which latter will be small,) $1. 08 or				0	5	5

So far as regards the cost of delivering the water into the Distributing Reservoir, the works will require a mere trifle to add the third wheel and its set of pumps to provide a supply for double the number of inhabitants. The expense of distribution will be increased as the City increases geographically, and though the increase in expense will not equal the increase in population, it may be assumed at the same ratio, and the charge for water, when such increase takes place in the population, will be for 120,000 people.

Original cost of works, namely:			
To and including Distributing Reservoir, as above,.....	£176,000	0	0
Add for third Wheel and Pumps, and for enlargement of Distributing Reservoir, probably.....	14,000	0	0
	190,000	0	0
Distribution Pipes at £1 5s. for 120,000.....	150,000	0	0
	£340,000	0	0
Annual cost, £340,000 at 6 per cent.....	20,400	0	0
Annual cost for maintenance and managing the works to deliver the water into Distributing Reservoir,.....	1,750	0	0
Total annual cost, for 120,000 people,.....	£22,150	0	0
The cost per inhabitant, when the supply is provided for 120,000, will be:			
For construction, the outlay will be, ...	£2	16	8
Or annual expense, including interest on capital expended in construction, ...	0	3	8

How far the City may be disposed to look in anticipating provision for its growth, I cannot determine! if, however, we regard the improvements likely to take place, and their influence on this City as an important commercial centre, it appears reasonable to conclude that its population will reach the number assumed in the preceding calculation at no very distant period, and quite within the limits that in a prudent forecast should lead to the anticipation of such preliminary provisions for a supply of water as are involved in the proposed plan. The saving that could be effected by erecting works to meet only the supply of the present inhabitants would be very small, and would involve a plan of works subject to continual change in its main features.

I have taken up the subject of Distributing Pipes, though that does not enter into the plan of Mr. Keefer, because they will be indispensable to the enjoyment of the work. The City has now a considerable quantity of pipe laid down, which no doubt will enter into any plan for general distribution and so far reduce the expense of this portion of the work.

The question necessarily arises—is there any plan that is more feasible or more advantageous than that proposed by Mr. Keefer? The situation of the City, as remarked by Mr. Keefer, precludes the idea of obtaining a supply by gravitation. Pumping is no doubt the means that must be used, and the only question is whether steam or water power shall be used. If water power is to be used, I have seen no means so well adapted to the object as the plan submitted by Mr. Keefer.

As fuel is rather expensive at this place, it is most probable the Cornish engine would be most economical for steam power. This class of engine is more expensive in construction, involving a larger outlay but requires less fuel to work it than ordinary engines, and would probably be most economical in this location. The cost of this class of engines would go far towards the cost of the Aqueduct; the question is—would the extra capital, involved in the outlay for water power, be equivalent to the increased annual expense of maintaining steam power? To establish steam-pumping, the most economical arrangement would be to take the water from the river at a point where it receives the drainage of the greater part of the City and below the shipping and canal. This would be very objectionable, on account of the general repugnance to using water for domestic purposes taken from a situation exposed to so much impurity, and could not be recommended. If the steam engine be placed so far above the City as to get clear of the difficulty of placing a suction pipe out of the reach of the ice, the extra expense of conduit pipe will make the expense of establishing the work for steam power, in original outlay, nearly as great as for water power. If the water must be taken in either case from near the same point in the river, which appears the only method of obtaining it in requisite purity, then there can be no such difference in the outlay of capital as would provide the current extra expense of maintaining steam over water power. The repairs and insurance

would be greater for an establishment for steam pumping than for water pumping. If the water could properly be taken for steam pumping below the principal city drainage, it is probable there would be about the same result as to cost, by either method, for a quantity not exceeding 2,500,000 gallons per day. For the larger quantity of 5,000,000 gallons per day, water power from the pure source would be more economical than steam power from the objectionable source. In view of the premises, there does not appear to me any reasonable doubt that water power in this locality is decidedly the proper plan to be adopted. It is proper to remark that the situation is eminently favorable for establishing a water power for the purpose. The works will be very secure from any action that could impair their regular operation or involve any considerable repairs.

On the most careful examination I have been able to make, I have no hesitation in the opinion that the plan proposed by Mr. Keefer is the best that can be adopted, to supply your City with an abundance of good water. I have for greater caution somewhat raised his estimate of the cost, but it is still moderate for the benefits it will secure.

The proposed work, as compared with others established for a similar purpose, will involve a moderate cost, and once in efficient operation, will be well worth all its expense, in the security it will afford against loss and damage by fire; and the varied and large benefits that will be experienced from domestic and manufacturing uses, for washing streets and for ornamental purposes, may be regarded as a clear gain to the City. The expense of supplying a large city with an abundance of good water is often dreaded in projecting the works, but when the flow enters the city, and its inhabitants experience the benefits, the question of cost is lost in the numerous advantages that never fail to be realized from an abundant supply of pure and wholesome water. Instance the great expense of the works established for

this purpose in New York and Boston, yet no word of complaint is heard that they have cost more than they are worth, nor would a proposition for their be listened to for hardly any amount.

Permit me, before closing this communication, to suggest that a Map of the City be prepared, shewing the present distribution, with a view to arrange the further piping, so as to make the distribution most effective for extinguishing fires, as well as most beneficial in supplying every locality with an efficient head and flow of water. On the judicious arrangement of distribution depends much of the advantage in a good supply of water.

The position designed by Mr. Keefer for a Distributing Reservoir is on ground very well adapted to the object; the inclination of the surfaces, though as favourable as any I have seen, with a substratum of rock, will make it rather expensive to excavate as compared with level ground wholly in earth, still it will not be such as to make this a serious objection. Its situation for distributing to all parts of the City is highly favourable; it may be constructed so as to be very secure from accidents. It will not be exposed to injury from the dust of streets. A natural ravine will afford a good channel to carry surplus water from the waste weir. Its banks may easily be constructed so as to make fine walks on the top from which the whole City, the river, and surrounding country are seen, and will present a view of great beauty and magnificence. Should the City be disposed to cultivate the vacant ground on the plateau, south-easterly from the site of the Reservoir, which is nearly 100 feet below, it would afford the opportunity of a fine Park, where fountains of water may rise and play with great beauty, and contribute much to the enjoyment of your citizens. This may not be deemed an important or necessary benefit, at the same time it is no doubt useful as well as ornamental. To combine works of art with those of nature so as to please and occupy the mind, is produc-

tive of substantial benefits to a community, and when the opportunity is presented to attain such objects at moderate cost they may be regarded as of substantial utility, and though not constituting the great and paramount objects of such improvements, you will doubtless regard their consideration as worthy of attention.

Though perhaps wholly uncalled for, I may be allowed to remark that in my intercourse and discussion of this subject with Mr. Keefer, I have had much pleasure in finding him an Engineer of intelligence and capacity, and his plans, so far as matured, evince much practical experience and sound judgment.

Respectfully submitted,

JOHN B. JERVIS,
Civil Engineer.

REPORT OF W. J. McALPINE, ESQ.

ALBANY, *26th May*, 1853.

DEAR SIR,

I have been furnished with your report upon the "Preliminary Surveys for the Water Supply of Montreal," together with a map, profile and cross section of the proposed Canal, and a copy of the specifications for constructing the work: I have also received from you, through Mr. Wm. A. Perkins, verbal explanations in regard to the detail of the proposed plans, as well as his observations of the ground, made during a recent visit.

This information, together with a personal knowledge of the localities at and near Montreal, enable me to furnish the following opinions on the plans you have submitted.

I fully concur in your remarks upon the subject of obtaining a supply from the drainage of districts elevated above the highest parts of the City.

The topographical features of the Island of Montreal are such as so preclude every hope of deriving a sufficient supply by gravitation, and hence it is obvious that it can only be obtained from the St. Lawrence and must be elevated by mechanical power.

The fall in the River contiguous to the City affords the means of securing an ample hydraulic power for this purpose. The choice, therefore, lies between steam and water power.

The comparative expense of constructing, maintaining and operating the works must be considered, in drawing a comparison between these two modes of obtaining a supply.

The water should be delivered into a reservoir as near the centre of the City as practicable, and from thence served to the consumers under a head of not less than fifty feet.

The Mountain in the rear of the City offers several favourable sites for the construction of a reservoir at the required altitude, and an elevation of two hundred feet above low water in the harbour is deemed sufficient to command all the buildings in the City.

A supply of two millions of gallons per day would undoubtedly meet every demand of the present population: but it would not be sound policy to construct the proposed works with only sufficient power for yielding that supply. In my opinion your works should possess the capacity of affording to the City five millions of gallons per day.

The necessity of elevating a part of the whole supply to the height above named will be subsequently discussed.

The elements for a comparison between the steam and water pumping plans will then be as follows: by steam power,

Five millions of gallons raised two hundred feet high in twelve hours.

By water power,

Five millions of gallons raised one hundred and sixty feet* high in twenty hours.

The length of the rising main from the steam pumps is seven thousand five hundred feet; and that from the water wheels thirteen thousand feet, the interior diameter of each will be taken at thirty inches.

The duty to be performed by the Steam Engine will be:

5,000,000 gallons at 10 pounds.	50,000,000 pounds.
200 feet high.	10,000,000,000 "
Or raised one foot high per minute,	13,888,888 "
Add one-fifth for friction of machinery,	2,777,777 "

Friction of water through pipe determined by the formula $P = \frac{q^2 l}{140\ d^5}$

$Q = 5{,}000{,}000 \div (12 \times 60 \times 60) = 115{,}74$

Say 120 gallons per second = 7,500 feet or 90,000 inches, $d = 30$ inches.

*The surface of water in the proposed Canal at the pumps will be about forty feet above the low water in the harbor, thereby reducing the height to which the water must be raised.

Then $P = \frac{120^3 \times 90000}{140 \times 30^2}$ $d = 45\frac{7}{10}$ which $\times$ 33,000 = 1,508,100 lbs

Total duty,..... 18,174,765 "

An Engine for performing this duty would require a steam cylinder of seventy two-inches diameter, twelve feet stroke, twelve revolutions per minute: steam cut off at one-fourth stroke, and working with a mean effective pressure of fourteen pounds per square inch.

The duty to be performed by the Water Wheels will be:

5,000,000 gallons at 10 pounds.	50,000,000 pounds.
160 feet high	8,000,000,000 "
Or raised one foot high per minute,	6,666,667 "
Add one-fifth for friction of machinery,	1,333,333 "

Friction of Water through pipe $= P \frac{70^3 \times 156,000}{140 \times 30^2}$

$= 15\frac{7}{10}$ which $\times$ 33,000 = 518,100 "

Total duty,..... 8,518,100 "

The quantity of water which will be discharged through the Canal you purpose to construct, as computed from the most reliable formula, is 19,600 cubic feet per minute; and this quantity falling through a space of sixteen feet upon breast wheels will create an effective power of about four hundred horses. This power is much more than that required for elevating the supply; but it should be distributed upon four wheels of the size recommended in your report, viz: twenty feet diameter, with twenty-two feet length of bucket, each wheel driving one pump.

With such an arrangement the machinery will possess greater security from accidents than if the same power were taken from two wheels, while at the same time the expense of running, repairs, and original outlay, will be but slighty increased.

It will be observed that the great difference in the amount of duty required of the two engines, is mainly caused by the time in which the water wheels can work being so much longer than that allowed to the steam

engines. Steam pumping engines should be arranged, when practicable, so as to work only by day-light, as the hazard of the breakage of the machinery is increased by night service, and it is also attended with extra expense in running.

The attendance upon the machinery of well regulated pumps driven by water wheels is seldom varied, whether the wheels are still or in motion, one person only being required on the watch, and his service all that is wanted for maintaining the operation of the machinery during the hours of the night.

The average daily work of the Turbine wheel recently erected at Fairmount, was for the month of May last 20 $\frac{17}{100}$ hours: and for other months, it varied with the demand, from 11½ to 15½ hours.

The water wheels, driving the pumps for supplying brine to the Syracuse salt works, operate for several months continually, and are only stopped to receive repairs.

The estimated cost of running a steam engine of the dimensions above stated, for elevating five millions of gallons, two hundred feet high in twelve hours, is as follows:

12 tons (2000 lbs.) of coal per day	a $4,	$48,	equal per annum		$17,520,00
1 Engineman, per day,	a $2,	$2,	"	"	730,00
2 Firemen, "	a $1.25,	$2.50,	"	"	912,50
Oil, Tallow, &c., "	a $3,50				1,277,50
Repairs of Engine and Machinery,					1,000,00
The age of the Engine and Machinery may be assumed to be equal to an annual cost of,					4,000,00
Total cost per annum,					$25,439,00

This sum is equal to the cost of elevating one thousand gallons of water for one and a half cents. The consumption of one pound of coal is estimated to be sufficient to raise 420,000 pounds of water one foot high.

By some experiments recently made at the Buffalo Water Works, the consumption of one pound of coal was found to be sufficient to raise from 350 to 360,000 pounds of water one foot high, including the consumption of fuel in raising steam before starting the pumps.

Some of the best Cornish engines have averaged as high a duty as one million of pounds with the consumption of one pound of coal.

The only valuable experience which has been had upon this continent in supplying water to Cities by water power, is at the Fairmount Works, Philadelphia. Mr. Frederick Graff, the superintendent of those works, has, in his annual reports for 1850, and 1852, given the cost of raising one million of gallons ninety six feet high per day at $1.61, for the former year, and $1.33 for the latter. These sums include the items of wages of workmen, tallow, oil, packing yarn, fuel for heating the mill house, and repairs to the wheels and pumps. Add to the above an item representing the age of the machinery or its depreciation in value, and we would find the total expense of performing the duty alluded to, about two dollars. This is equivalent to the cost of elevating one thousand gallons of water for one-third of a cent.*

The cost of elevating the same quantity by steam power has been before stated at one and one-half cents, making the proportion of the cost of water power to that of steam, about four and one-half to one.

If the interest on the cost of the Canal and works to bring the water to the wheels is added, applied to the raising of five millions of gallons per day, it will increase the cost of the water power, to about one and one-quarter cents for elevating one thousand gallons.

The cost of elevating five millions of gallons daily at the above rate is per annum about $6,000.	
The interest on the difference between the cost of the Canal and water power, and of the steam power, and its appurtenances (say $250,000 *a* 6 per cent.) is,	15,000
Total,	$21,000
Cost per annum of pumping by steam power,	25,439
Making an annual saving of	$4,439

*This estimate is made for elevating the water one hundred and sixty feet high, while that by steam power is for elevating it two hundred feet high. If allowance is made for this difference in the elevation, the proportionate cost would be as three and a half to one.

The capacity of the water power during a greater portion of the year will be double that which has been estimated. This excess of power can be usefully applied to other purposes, and thus render the comparison between the expense of the two plans, still more in favor of water power.

I am, therefore, of the opinion that your plan of pumping the water by water power will be more economical to the City, than if steam were applied.

The use of water wheels in so cold a climate as that of Montreal, may be objected to on the ground of the liability of their operations being suspended by the action of the ice. The experience you have of the performance of the wheels upon the Lachine Canal will enable you to judge of the value of these objections.

Should you apprehend considerable difficulties in the use of the wheels proposed, I would recommend the adoption of the Turbine wheel, as the danger of its being stopped by ice or back water is trifling if it be properly arranged and guarded.

The operation of this wheel at Fairmount Works has given entire satisfaction. The Superintendent in his last report alluding to it, says, "the perfect success of this wheel affords the means of increasing the power of the works, (by substituting Turbines for the breast wheels now in use) to the extent of from four and one-half to six millions of gallons per day.

It may be possible to add to the effective fall of water upon the wheels by lowering the tail race below the level you propose, and using the Turbine, which will operate in back water should you be troubled with it. If this can be done I should consider it the most judicious plan.

I would also suggest the advantage that may arise from terminating the canal at some point nearer the river than Gregory's, and thus obtaining a tail race several feet lower than the one proposed.

Your machinery would then be exposed to the action of freshets, and the wheels, for a certain period of time, be compelled to work in back water.

This objection would be quite removed by properly closing and guarding the mouth of the race, and using the Turbine instead of the breast wheel.

The liability to derangement in all mechanical contrivances renders it advisable to provide to a supply in the event of an accident causing a suspension in the operation of the pumps.

During the prevalence of extensive fires when the consumption and waste of water is very great, there is much danger of the pumping machinery being run at hazardous rates of speed, thereby increasing the risk of breakage at a time when its failure would be disastrous.

The duplicating of the machinery, and also of the rising main is therefore indispensable, unless a Reservoir be constructed of sufficient capacity to retain a supply for the City during the existence of the breach.

I have already recommended the use of four wheels with one pump attached to each; the question now is upon duplicating the rising main or making reservoirs of great capacity.

Should the first named measure be resorted to, the diameter of the mains may be reduced. The cost of one these lines, say of twenty-four inches diameter, from Gregory's to the McTavish Reservoir, will be, when laid complete with all the necessary fixtures, about eighty thousand ($80,000) dollars.

With double mains and duplicate machinery, the risk of a failure of supply will be mainly confined to some derangement in the canal and channels connected with the wheels, or to giving too great a speed to the machinery.

In reference to reservoir capacity it may be said that the experience of every city supplied with water, fully attests the importance of holding at constant command in their reservoirs a large surplus of water.

Those having reservoirs of limited capacity are annually subjected to inconvenience from the defectiveness of this principal branch of their system.

The Corporation of Philadelphia have just completed, at an expense of fifty thousand dollars, a reservoir, the

contents of which are sixteen and a-half millions of gallons; they having found the old ones (which together held twenty two millions of gallons) inadequate to meet their wants.

They have also six rising mains and eight pumps.

The slopes of the Mountain in the rear of Montreal are too abrupt to admit of the construction of a large reservoir at a height which will command the whole city, and you will therefore be compelled to depend upon the constant operation of your pumps, or to erect a capacious reservoir on a lower level, from which the supply to the lower portions of the City may be drawn.

In determining which of these modes shall be resorted to, the arrangement of the distributing pipes has a particular influence.

If there be but one reservoir constructed, and that at an elevation two hundred feet above the harbour, there will be a large district of distributing pipes subjected to a head pressure, ranging from one hundred and sixty to one hundred and seventy feet. This is in my opinion quite objectionable, and wholly unecessary, except in cases of extensive conflagrations, during which time the draught of water from the pipes is so great as to render this head of the utmost importance.

There would also be a difficulty in using the present distributing pipes under the whole head of two hundred feet above the harbour. They would undoubtedly, in numerous instances, be blown up by the new supply, and with the rupturing of the house service pipes be the source of continued annoyance.

The plateau of ground lying between St. Denis and St. Lawrence Streets, and west of Sherbrooke Street, offers an eligible site for the construction of a reservoir with storage capacity.

The surface of water in this reservoir will be one hundred and forty feet above the harbour in low water, and will supply with an ample head all the buildings situate upon grounds not higher than that of Dalhousie Square.

The district thus supplied comprises the major portion of the city, and in case of the failure of the upper reservoir, all the inhabitants residing upon and below the level of Sherbrooke Street could also derive a sufficient supply for culinary purposes from the lower reservoir.

It is evident that by constructing the lower reservoir with storage capacity, all the danger of an interruption of the supply by the failure of the machinery is removed, and you will also derive an advantage which in similar works is conceded to be of much importance—that of retaining the purity of the water by holding it in large basins.

Much economy may be practised in laying down the distributing conduits, by creating a high and low service, as the thickness of pipe required for the lower service will be diminished by only using the upper head at times when a great supply is wanted. You will also be enabled to use the pipe now laid to better advantage.

The cost of the lower reservoir, capable of holding thirty millions of gallons, having the water from fifteen to twenty feet deep—made of earthen mounds with interior puddle walls, and paved upon the insides, will be about forty thousand dollars.

This reservoir may be supplied by a distributing pipe laid from it through Sherbrooke Street to the rising main. By this plan a saving will be effected in the outlay for machinery, and also in the power, should the day come when it will all be needed.

The single rising main will on this plan afford perfect security, and the saving thereby made as compared with the cost of the lower reservoir amounts to about forty thousand dollars.

I therefore recommend the following plan, the erection of duplicate wheels and pumps; a single rising main of thirty inches diameter; the construction of a small reservoir on the McTavish place, and of a large storing one upon the site of the present reservoir, the feeding of this reservoir through the distributing pipe in Sherbrooke Street; and the laying down of two services that may be connected in cases of fire.

The pumping main should be disconnected from the distributing pipes when the pumps are running, except in emergencies, as the impulsive action of the pumps would tend to produce leaks in the joints of the distributing and house pipes.

In the arrangement of the two services care should be taken to connect them at convenient places by cross pipes and stop cocks, by which means the whole head can be turned upon all the pipes during conflagrations.

The distributing pipes should have a capacity sufficient to furnish the requisite supply in case of fire, and this can be obtained at a reasonable expense by enlarging each alternate or third pipe, which would in such cases become feeders to the intermediate pipes.

Both services should be separated into distances of moderate size by stop cocks, so that when repairs are required the supply shall only be cut off from a limited district.

I also recommend the laying down of an independent main from the lower reservoir through St. Denis or St. Constant Streets to Notre Dame Street, for the purpose of supplying the ridge on the City's front.

This main should not be tapped by either street or house service pipes, and should be arranged to connect with the upper service on the level of Dorchester Street.

The main from the McTavish Reservoir should be produced through the town service, passing down Mansfield and St. Monique Streets, the upper pressure being terminated at St. Antoine Street.

I have examined the estimates which you have submitted, and believe the sum therein provided for to be sufficient to complete the works you propose. That is for the canal, wheels, machinery, rising main, and reservoirs—the sum of six hundred thousand dollars.

Very truly yours,

WM. J. McALPINE.

Thos. C. Keefer, Esq., Engineer,
Montreal Water Works.

APPENDIX.

In my preliminary report no allusion was made to the quality of the water, further than a general remark that the point at which it was taken out of the St. Lawrence was the most favourable possible for a pure supply. As there was no choice, a chemical analysis was not necessary. I was then anxious, however, to ascertain the extent of the improvement in the quality of the water which might be expected by taking the supply from the head of the Lachine Rapids, instead of from the foot of the harbour as is now done.

The effect produced upon many travellers by the water now taken from the harbour is well known, and has never been accounted for. Although I by no means expected to solve so subtle a question, I deemed it of the utmost importance, in connection with the new supply, that every information should be obtained bearing upon this point.

The water flowing in front of the city is a mixture of the Ottawa and the St. Lawrence, both good waters separately, and it would appear a paradox, that a mixture of two good things would result in a deleterious one. No complaint, that I am aware of, has been made of either the Ottawa or St. Lawrence waters, by travellers on steamers where these waters were exclusively used; and from the testimony of the Captains of steamers, I am aware that both of these waters may be drank with impunity by persons who are immediately and severely affected by the water now supplied to this city.

At Montreal the sample analysed from the present Water Works was obtained under the most favourable circumstances, and was probably more of a St. Lawrence than an Ottawa water. The city is at present supplied by a "suction" pipe laid under the long-wharf, and drawing its supply from the outer end near the channel. In

winter, the elevation of the water allows the Ottawa, which hugs our island, to flow inshore over this wharf. At this season, also, there is very little sewage discharge at Pointe à Callière, and this passes over the wharf between the mouth of the suction pipe and the shore. In summer, however, the case is very different. When the water falls below the level of the long-wharf, all the sewage discharge from Pointe à Callière, with the offal, &c., thrown overboard from the shipping, are mixed with Ottawa water—already turbid and heated from flowing over the shallows at Nun's Island and Pointe St. Charles—and from constant disturbance by the steamers of the shallow shoals in the harbour—and are drawn round the head of the long-wharf into the channel, just over the point where the supply is taken for the pumps.

To appreciate the effect of the Pointe à Callière sewage which thus flows over the mouth of the present feed pipe, it is necessary to refer briefly to the topography and drainage of Montreal.

None but the older residents, or such as interest themselves about the drainage area of streams, may be aware that the whole water shed from the Tanneries village to a point opposite Longueuil, and from the line of Notre Dame and St. Mary Streets, as far back as the summit of the mountain, was originally discharged at Pointe à Callière opposite the Custom House, and that the only reduction of this discharge is that occasioned by a tap from the Craig Street sewer cut through into the Current St. Mary near Monarque Street. Under such a condition of things the sewage discharge cannot be regular, and such as would be neutralized by the greater volume into which it pours. For with such an extent of area to be drained at one point, and with the insufficient fall existing, in dry weather little discharge will take place, and a periodical flushing must ensue, after every heavy rain or thaw, which will pour into the harbour such a quantity of sewage at one time as cannot fail to influence the quality of water delivered by the pumps.

Without determining whether dirty water is unwholesome—or produces the strong medicinal effect which our present supply is known to exert on many constitutions, it is apparent that a state of things exists which will fully account for a difference in the quality of the water in front of the city from that of the parent rivers, or of any admixture of them above or below us.

It is also a popular belief that the St. Lawrence is a purer because a whiter water than the Ottawa, but those who have used both must have remarked that the latter is the softer of the two, and this quality, in an economic point of view, makes it the most valuable for public use.

It has been asserted that the Shad and Salmon ascend the Ottawa in preference to the St. Lawrence, a fact which, if well established, is an argument in favour of the superior purity of the Ottawa water.

In order to ascertain first, the relative qualities of the Ottawa and St. Lawrence waters,—pure samples of each were taken out of the respective rivers *above* the rapids of Ste. Anne, and the Cascades, in the month of March, when no freshets or land drainage existed; and, secondly, in order to determine whether there was any important commingling of the two before they pass Montreal, samples were obtained, at the same period, above the Lachine rapids, and from the wells of the pumps now supplying the city.

It will be seen from Mr. Hunt's analysis that the Ottawa water, as found above Ste. Anne, already undergoes decided changes before it reaches the Lachine Rapids, and that this effect of its contact with the St. Lawrence water is still further heightened by the time it reaches Montreal.

It should be observed, however, that the quality of the water at Lachine will vary very much from the results shewn by the analysis, as there is a different proportion of the Ottawa thrown into Lake St. Louis for almost every month in the year.

One of the most important questions connected with the properties of water for the supply of towns is, the probable action upon lead. The use of this metal for house service is indispensible, and it is well established that the more pure the water the greater is its action upon lead. The water with which Boston is supplied is purer than that of any other American city, and, although its action upon lead is disputed, a most alarming action on the iron mains has developed itself, which has (by nodules or accretions in the interior of the pipes) reduced the capacity of some of the large mains very materially. Mr. Hunt's analysis shews that unmixed Ottawa water contains less than one-third of the quantity of carbonate of lime which is held in solution by an equal bulk of St. Lawrence water; and that this quantity is consider[illegible] more than doubled by its contact with the latte[illegible]achine. While this lime undoubtedly increases the hardness of the Ottawa water it confers upon it the property of resisting the action of lead. Good authorities say that soft water, when it contains less than $\frac{1}{5000}$ part of solid matter in the form of carbonates or sulphates, will act upon lead. Lime water is used to coat the interior of pipes. On referring to Mr. Hunt's letter it does not appear that the water of the new supply will contain more solid matter than is required,—and it is satisfactory to know from experience with the pipes which have been a long time laid down here, that no serious action on the iron is to be anticipated from the quality of the water which will be used.

THOS. C. KEEFER.

MONTREAL, 18*th April*, 18*64*.

MY DEAR SIR,

I have submitted to a chemical examination the waters of the St. Lawrence and Ottawa rivers, collected above their junction, as well as the waters of the united current below Lachine, and that supplied to Montreal by the City Water Works. The water of the Ottawa was taken by me in company with yourself, on the 9th of March last, at the head of the Ste. Anne lock, where there could be no admixture with the St. Lawrence, and on the same day, we took a specimen three miles below Lachine, at the point where the Corporation are about to obtain the supply for the new City Water Works, and about 30 feet from the shore. I collected the St. Lawrence water on the 30th March, at about 100 feet from the shore, on the south side of the Pointe-des-Cascades, at Vaudreuil, not far below the rapids. A portion of water was also taken from the well at the City Water Works, on the 15th of March. All of these specimens were thus collected before the melting of the snows, and may be regarded as representing the average character of the waters.

The water of the St. Lawrence, which is pure green in a large body, appears completely destitute of color, when in masses of only ten or twelve inches in thickness, while the fine amber-brown hue of the Ottawa is very distinctly seen in a common drinking glass. The water from Lachine and that of the City are nearly alike in color and while partaking of the brown hue of the Ottawa, have as I find by comparison, the tint of a mixture containing one part of this and two of pure St. Lawrence water. The waters are all bright and transparent, and deposit a very small amount of brownish sediment, which adheres firmly to the bottom of the bottles; the City water contains the most, and the St. Lawrence the least.

When the Ottawa water is boiled, it deposits a mixture of earthy carbonates and silica, colored dark brown, by the presence of a considerable amount of vegetable matter, which the recent water holds in solution. Owing to this admixture the deposit is not so dense as in the other waters, and adheres but slightly to the interior

of the glass vessel in which it is boiled. This vegetable matter which colors the waters of the Ottawa, is without doubt, derived from the peat bogs which are abundant in the regions drained by this river. It is only in part precipitated by boiling, and the water when evaporated to a small bulk, has the color of brown sherry wine. When the water of the St. Lawrence is boiled, it gives a white crystalline deposit, which is more abundant than that from the Ottawa, and adheres firmly to the surface of the vessel. There is but little color in the evaporated water, showing that vegetable matter is present only in very small quantity. The other specimens are mixtures of the two waters in which the St. Lawrence predominates, and yield by boiling crystalline deposits, colored by vegetable matter.

The most important results of my analyses are given in the following table; they are the means of two or more closely accordant determinations, and are calculated for 100,000 parts.

	Ste. Anne.	Lachine.	City W. Works.	Cascades.
Carbonate of Lime.....	2·480	6·440	7·400	8·033
Carbonate of Magnesia...	·696	1·970	2·160	2·537
Silica.....	2·060	3·250	3·450	2·380
Chlorine.....	·076	·152	·296	·242
Sulphuric Acid.....	·161	·487	·498	·687
Alkalies (as Chlorids)...	·900	1·810	not deter.	1·500

No attempt is here made to shew the distribution of the sulphuric acid and chlorine among the bases, and farther inquiries are necessary to decide some questions of theoretical interest, but the above table shows all that is necessary in order to judge of the fitness of these waters, for the ordinary purposes of life. The results of my further examinations when completed, will be given in the Report of the Geological Survey. It may be mentioned that in all these waters, minute portions of phosphoric acid, alumina, and of the oxyds of iron and manganese, have been detected; the quantity of manganese is greater in the St. Lawrence, but the Ottawa contains more iron. A portion of the vegetable matter in the latter water, exists in the form of crenic acid, which has been found in many other natural waters. When evaporated to a small volume, these waters still retain a portion of silica in solution and a little lime,

which in the Ste. Anne water amounts to ·13 and in the Cascades to ·28 in 100,000 parts.

It will be seen from the table, that the waters of the St. Lawrence are already mingled with the Ottawa at Lachine, for the water at the head of the Lachine Rapids, near the shore of the Island of Montreal, has the composition of a mixture of two parts of St. Lawrence with one of Ottawa water. In that from the City Water Works the admixture of St. Lawrence water is much greater, the proportions being about five to one. It must be remembered that the volume of the Ottawa varies greatly with the season, the water being lowest in February and September. In June and October when its volume is very much increased, the proportion of St. Lawrence water near the shore of the Island, will doubtless be much less than at the time when these specimens were taken.

It is important to remark that the amount of chlorids contained in the water at present supplied to the City, is greater than in the St. Lawrence water. Another sample drawn from a hydrant on the 11th of April, gave ·284 of chlorine, and a partial analysis of the water from the same source, made in the spring of 1850, showed a similar excess of chlorine. The results calculated for 100,000 parts were:

Carbonate of Lime,.....	7·550
Carbonate of Magnesia,.....	2·044
Chlorine,.....	·297
Sulphuric Acid,.....	·447

This constant excess of chlorids shows that there is a local source of impurity, probably the drainage of the City, which always affords a large supply of such salts.

The whole amount of solid matter, left after heating to redness the residue from the evaporation of the different waters, will enable us to make some comparisons with the water supplied to other cities. I give the results obtained by Prof. Silliman with the Croton water of New York, the Schuylkill of Philadelphia, the Cochituate water of Boston, and that from the river St. Charles, above Indian Lorette, at the point where it is taken for the supply of Quebec.

The results are calculated so as to show the amount of fixedresidue in an imperial gallon of ten pounds avoirdupois, or 70,000 grains.

Ottawa, Ste. Anne,.....	3·78	grains.
St. Lawrence, Cascades,.....	10·76	"
Lachine,.....	8·41	"
City Water Works,.....	9·62	"
Croton, New York.....	7·98	"
Schuylkill, Philadelphia,.....	4·95	"
Cochituate, Boston,.....	1·46	"
St. Charles, Quebec,.....	2·45	"

It will thus be seen that while the water from Lachine with which our City is to be supplied, is less pure than those of Quebec or Boston, it differs very little from the Croton, and is decidedly to be preferred to the unmixed water of the St. Lawrence, or to our present supply. The great purity of the Ottawa is more than sufficient to counterbalance the objection which its color offers, and it is therefore an important consideration, that during a great part of the year the increased bulk of the Ottawa, will give us at Lachine a supply of the water of this river with very little mixture of the St. Lawrence.

The action of these waters upon lead, is a question of interest; it is known that natural waters containing a considerable amount of soluble salts, especially sulphates, have less action upon this metal than purer waters, but I have found that both the St. Lawrence and Ottawa waters take into solution a certain portion of the lead; the latter, somewhat the larger quantity. The contact of brass with the lead increases the action of the water, probably by a galvanic action, while in contact with iron, on the contrary, the lead remained bright, and was less affected; the iron, meanwhile, was considerably corroded with the formation of red iron rust. The protecting influence which the iron mains might exercise over the ends of the lead pipes joined to them, would however, be in a great measure counteracted by the brass cocks.

I remain, my dear Sir,
Very sincerely yours,
T. STERRY HUNT.

T. C. Keefer, Esq.,

LEVELS OF WATER IN THE RIVER ST. LAWRENCE AT HEAD OF THE AQUEDUCT.

DATUM, SUMMER LEVEL OF WATER IN MONTREAL HARBOR.

Day of the Month.	1853. MAY.	JUNE.	JULY.	AUGUST.	SEPT.	OCT.	NOV.	DEC.	1854. JAN.	FEB.	MARCH.	APRIL.	MAY.	REMARKS.
1st.	.....	40.50	39.18	38.00	37.68	37.67	37.85	38.78	.....	38.35	37.05	37.32	40.75	
2nd.	.....	40.35	39.10	37.98	37.64	37.76	38.10	38.64	39.25	37.77	36.95	37.35	41.05	
3rd.	.....	40.32	39.03	37.92	37.60	37.85	38.00	38.51	.....	37.32	36.75	37.45	41.22	
4th.	.....	40.20	38.95	37.90	37.55	37.85	37.95	38.42	.....	36.94	36.77	37.45	41.34	
5th.	.....	40.15	38.93	37.90	37.55	37.85	37.94	38.35	.....	37.00	36.75	37.45	41.37	
6th.	.....	40.17	38.90	37.87	37.52	37.95	37.88	38.20	.....	37.05	36.72	37.57	41.40	
7th.	.....	40.18	38.90	37.87	37.52	37.95	37.84	38.12	.....	37.10	36.84	37.95	41.42	
8th.	.....	40.20	38.79	37.87	37.52	37.95	37.75	38.10	.....	37.10	36.92	38.20	41.35	
9th.	.....	40.24	38.63	37.87	37.52	37.95	37.87	38.05	.....	37.20	36.87	38.20	41.35	
10th.	.....	40.27	38.73	37.87	37.52	37.95	38.10	38.05	.....	37.25	36.90	38.17	41.33	
11th.	.....	40.29	38.69	37.87	37.52	37.98	38.10	37.98	.....	36.80	36.95	38.22	41 37	
12th.	.....	40.25	38.67	37.87	37.48	37.85	38.05	37.91	.....	36.80	37.05	38.35	41.35	
13th.	.....	40.19	38.59	37.87	37.48	37.85	38.09	37.93	.....	36.85	37.17	38.47	41.29	
14th.	.....	40.10	38.50	37.87	37.45	37.85	38.20	37.84	.....	37.25	37.30	38.50	41.28	
15th.	.....	40.10	38.50	37.87	37.55	38.10	38.20	37.82	.....	37.45	37.50	38.33	41.35	
16th.	.....	40.05	38.30	37.82	37.68	37.90	38.20	37.75	.....	37.30	37.52	38.13	41.36	
17th.	.....	39.99	38.33	37.77	37.80	37.95	38.10	37.77	.....	37.30	37.90	38.07	41.40	
18th.	40.17	39.95	38.30	37.77	37.85	38.00	38.13	37.85	.....	37.12	38.25	38.14	41.40	
19th.	40.35	39.87	38.25	37.77	37.90	37.95	38.22	.....	.....	37.15	37.85	38.14	41.52	
20th.	40.50	39.79	38.22	37.77	37.94	37.90	38.45	.....	.....	37.05	37.95	38.31	41.57	
21st.	40.50	39.66	38.22	37.77	37.94	37.90	38.51	.....	.....	36.75	37.95	38.29	41.72	
22nd.	40.53	39.57	38.22	37.77	37.90	37.85	38.62	.....	.....	36.90	37.90	38 31	41.86	
23rd.	40.59	39.48	38.22	37.75	37.90	37.85	38.65	.....	.....	37.05	37.67	38.37	41.93	
24th.	40.70	39.42	38.20	37.69	37.90	38.00	38.72	.....	.....	36.85	37.70	38.46	41.95	
25th.	40.73	39.40	38.19	37.69	37.80	38.00	38.75	.....	.....	36.80	37.60	38.53	41.98	
26th.	40.75	39.39	38.19	37.69	37.70	38.00	38.75	.....	.....	36.42	37.45	38.77	41.98	
27th.	40.80	39.26	38.17	37.69	37.60	38.25	38.80	.....	.....	37.00	37.32	39.20	41.96	
28th.	40.85	39.23	38.15	37.69	37.55	38.20	38.80	.....	.....	37.15	37.32	39.62	41.92	
29th.	40.84	39.23	38.10	37.69	37.57	38.20	38.85	.....	.....	.....	37.25	40.10	41.86	
30th.	40.75	39.19	38.09	37.69	37.72	38.10	38.84	.....	.....	.....	37.32	40.40	41.60	
31st.	40.60	.....	38.05	37.69	.....	37.90	.....	.....	38.27	.....	37.20	.....	41.57	

The assumed low water level at head of Aqueduct is 36.00, and the excavation is made eight feet below this point. It will be seen, that the lowest water last year was on 26th February, when it fell to 36.42, for a day—probably caused by a temporary dam of ice opposite Lachine.

LEVELS OF WATER IN THE RIVER ST. LAWRENCE AT HEAD OF THE AQUEDUCT.

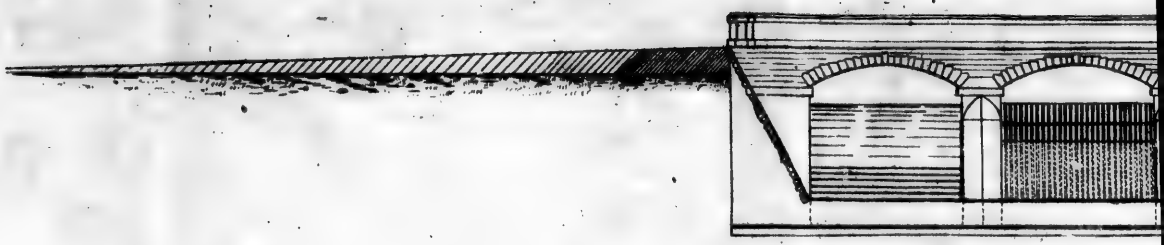
DATUM, SUMMER LEVEL OF WATER IN MONTREAL HARBOR.

Day of the Month.	1853. MAY.	JUNE.	JULY.	AUGUST.	SEPT.	OCT.	NOV.	DEC.	1854. JAN.	FEB.	MARCH.	APRIL.	MAY.	REMARKS.
1st.	.....	40.50	39.18	38.00	37.68	37.67	37.85	38.78	.....	38.35	37.05	37.32	40.75	
2nd.	.....	40.35	39.10	37.98	37.64	37.76	38.10	38.64	39.25	37.77	36.95	37.35	41.05	

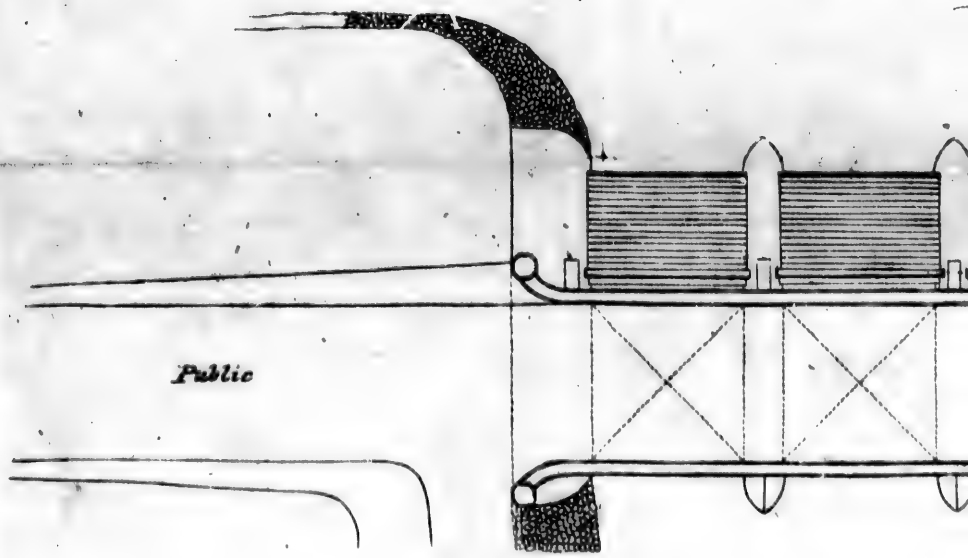
Montreal Water Works.

DETAILS.

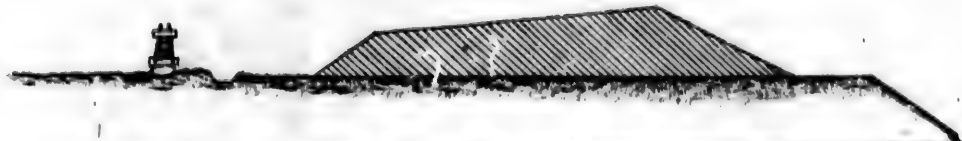
Matthews' Lith.

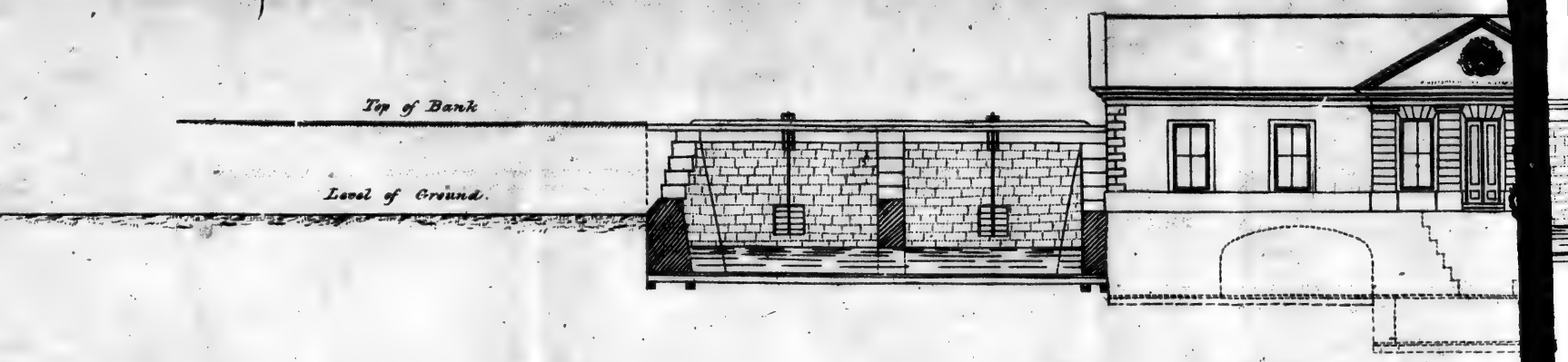


ELEVATION OF STOP GATE

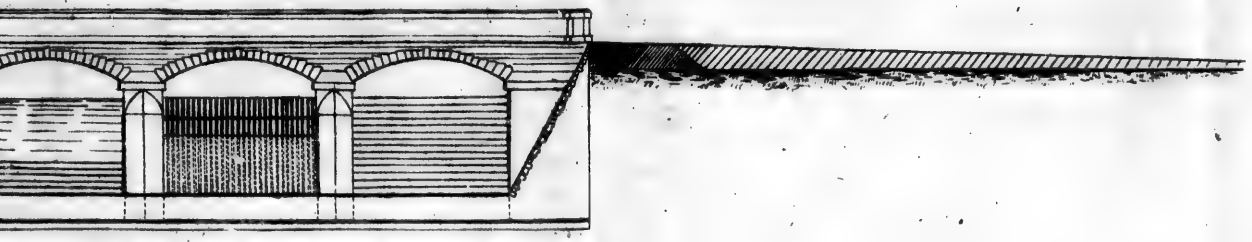


PLAN OF STOP GA



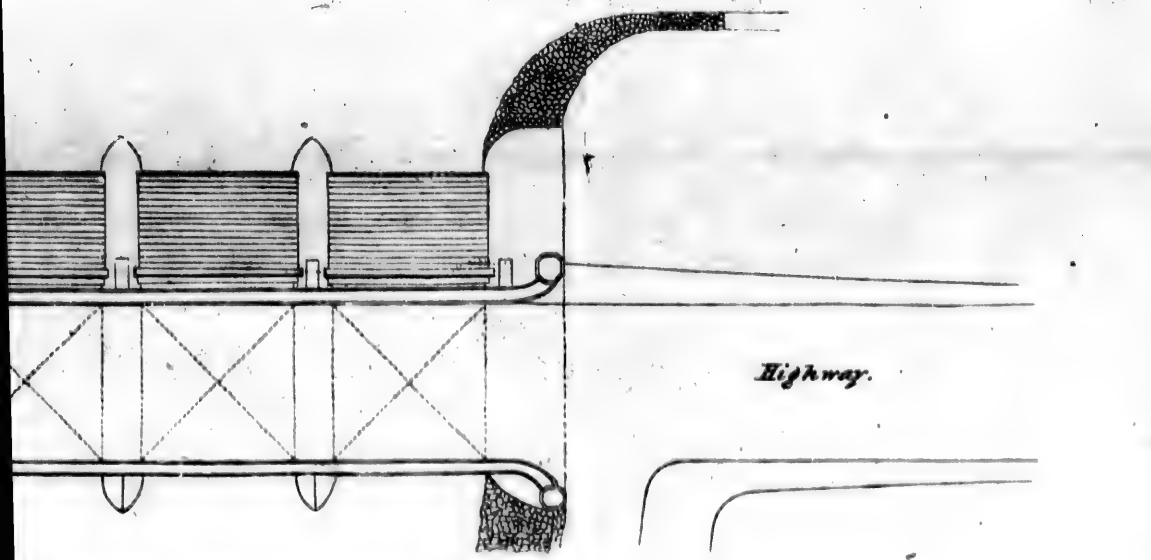


ELEVATION OF PUMP

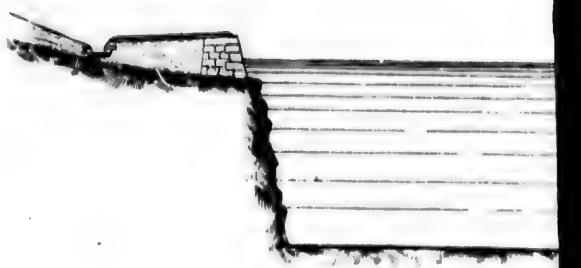


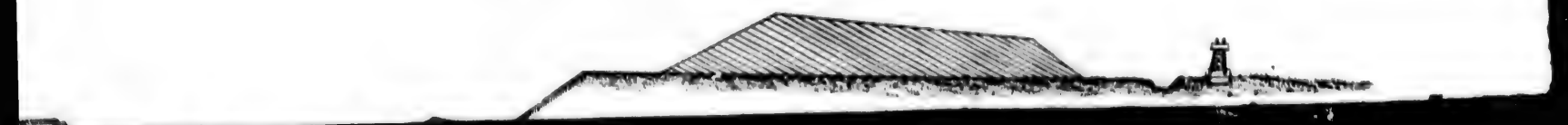
ON OF STOP GATE AT ENTRANCE.

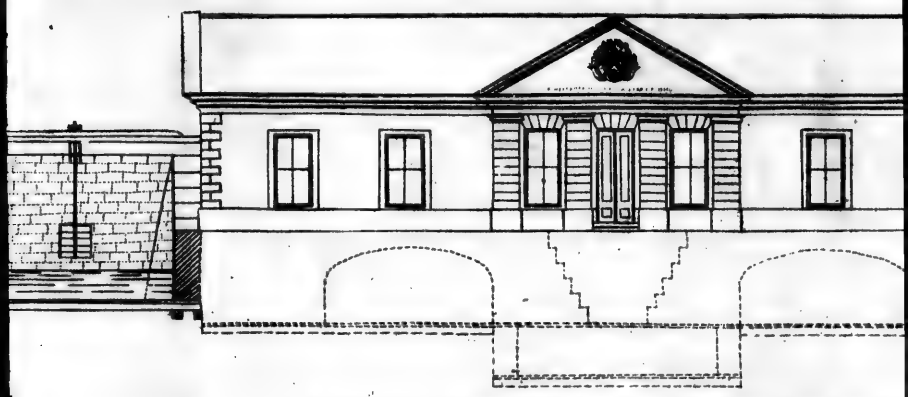
SECTION



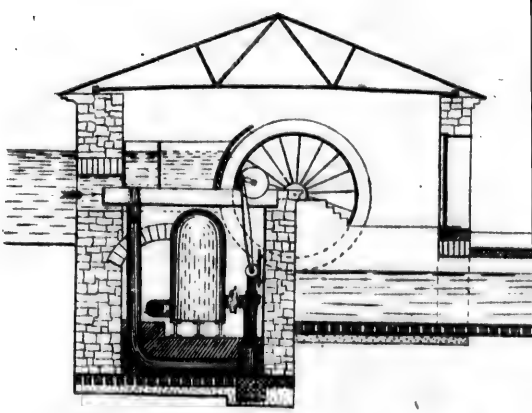
PLAN OF STOP GATE.



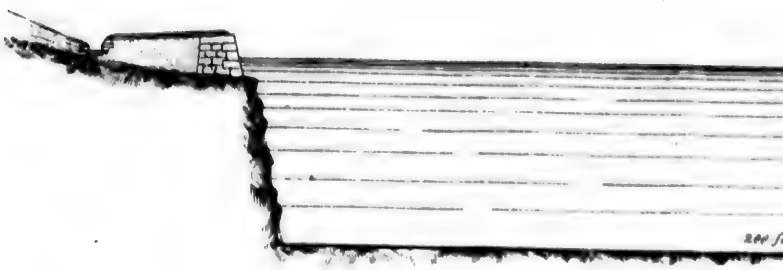




ELEVATION OF PUMP & WHEEL HOU



SECTION OF WHEEL HO



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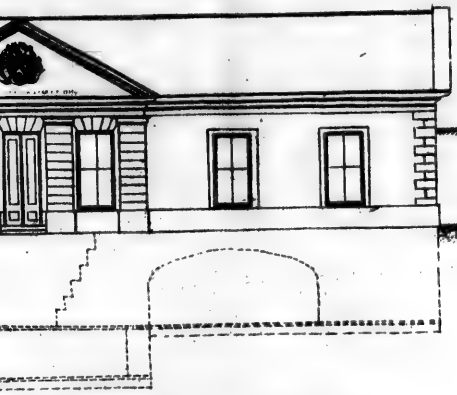
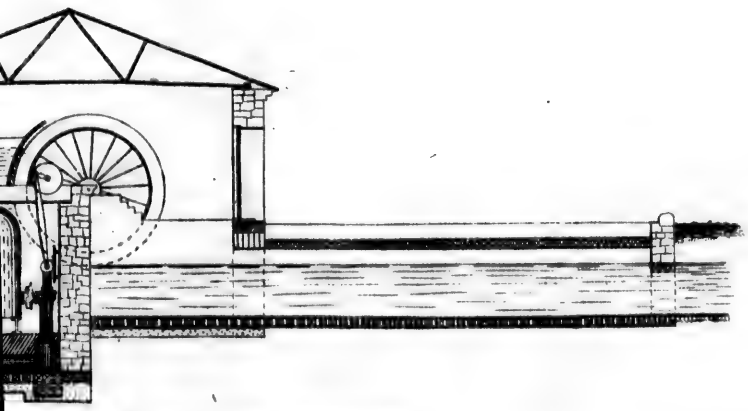
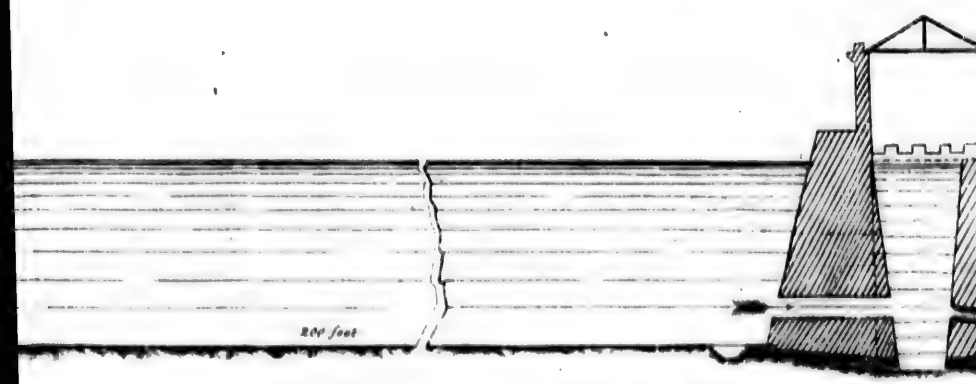


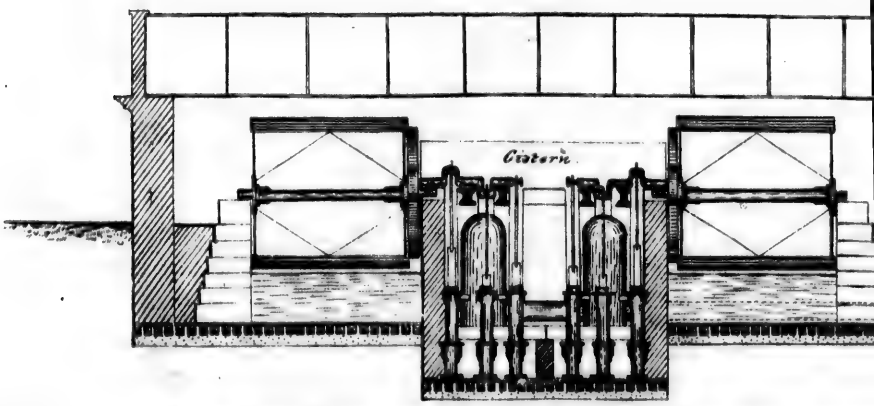
PUMP & WHEEL HOUSE.



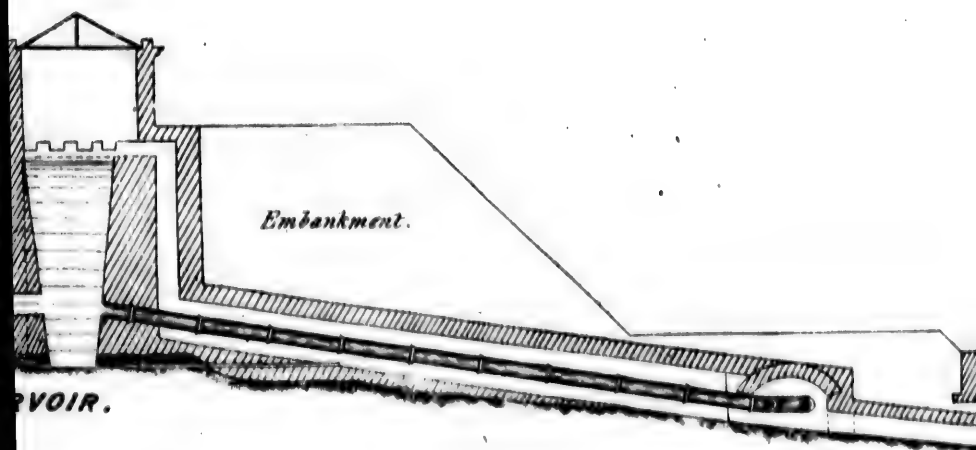
TION OF WHEEL HOUSE.



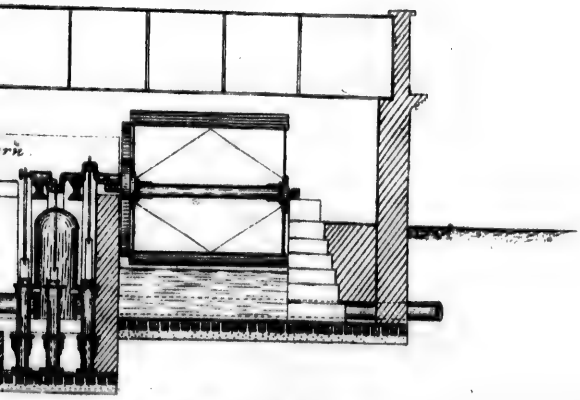
SECTION OF DISTRIBUTING RESERVOIR.



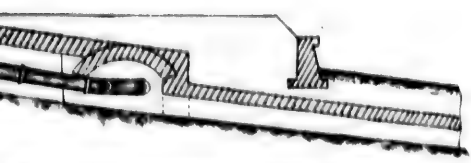
SECTION OF WHEEL HOUSE & PUMP ROOM



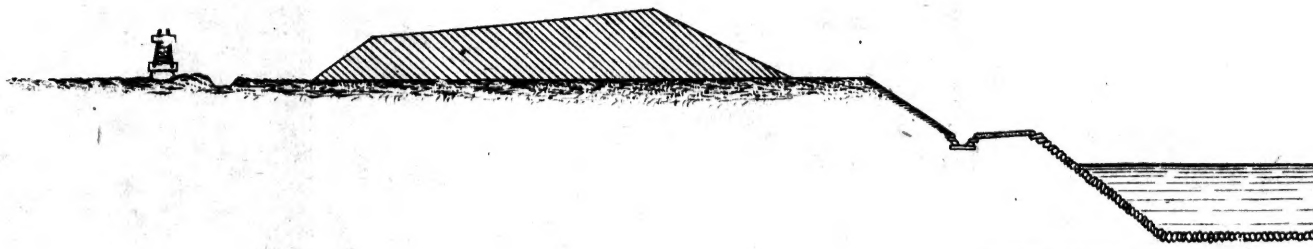
RVOIR.



OUSE & PUMP ROOM.



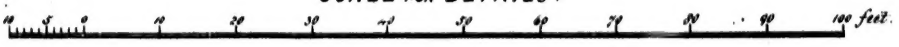
PLAN OF STOP GA

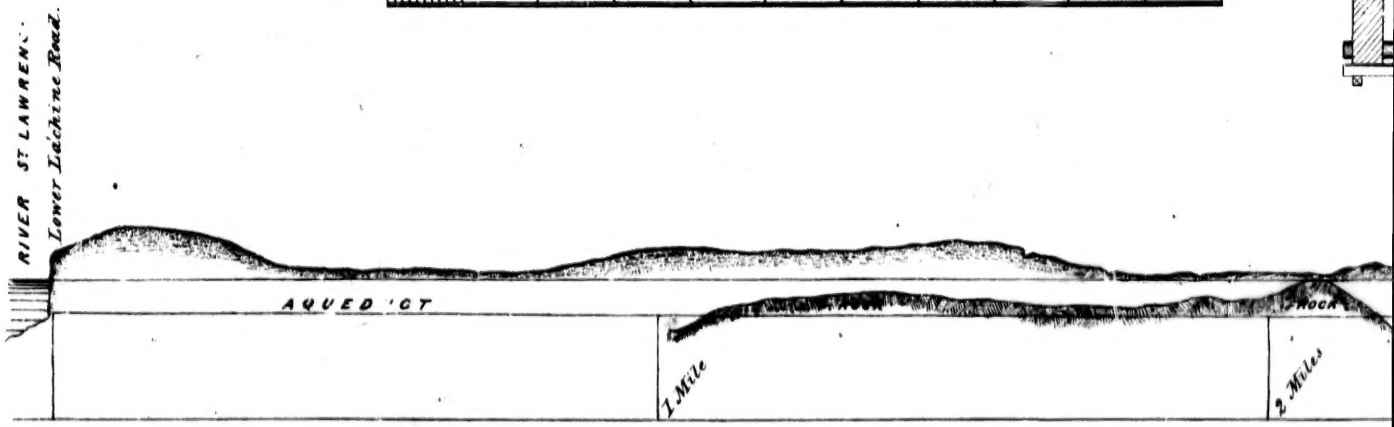


SECTION THRO' DE

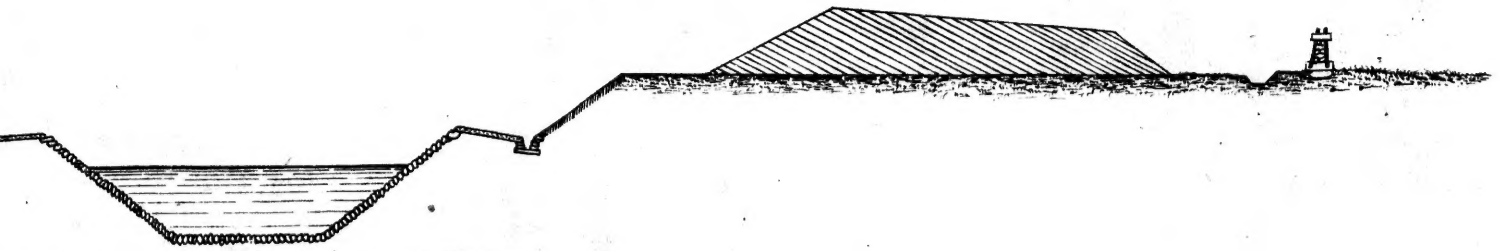
SECTION THRO' E

SCALE FOR DETAILS.

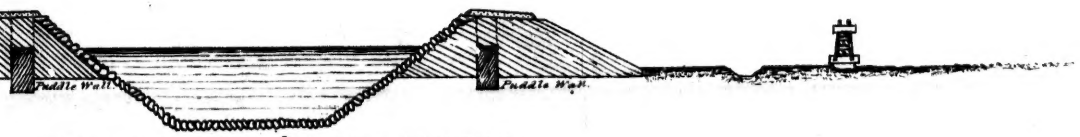




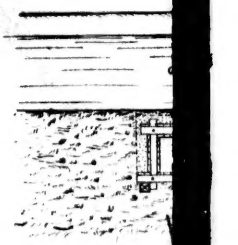
PLAN OF STOP GATE.



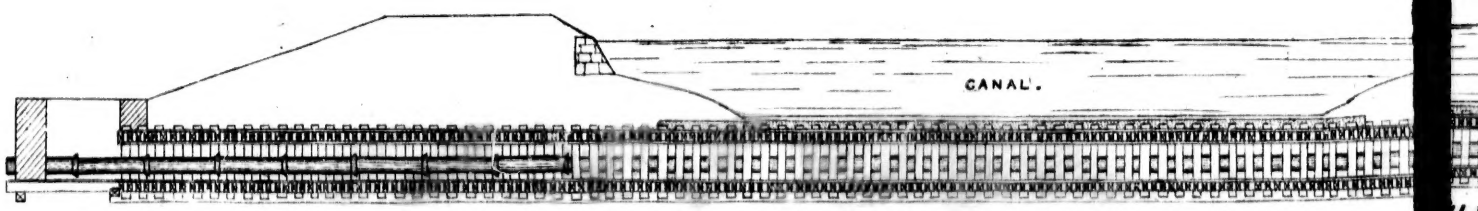
ECTION THRO' DEEP CUTTING.



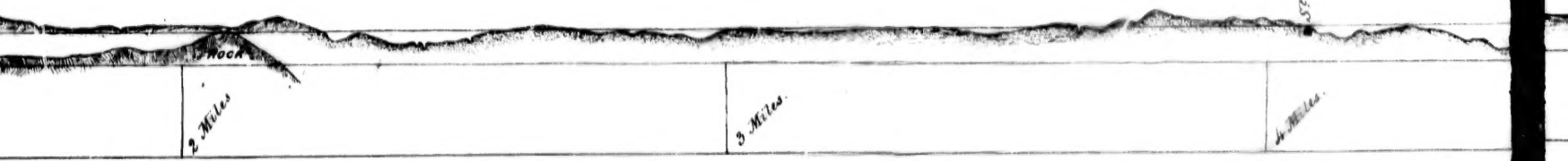
SECTION THRO' EMBANKMENT.



SECTION



PIPE CULVERT UNDER LACHINE CANAL.

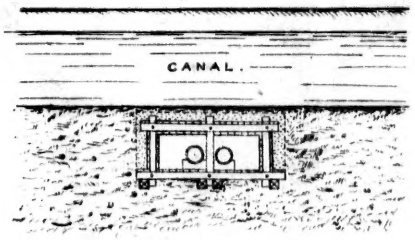


LONGITUDINAL SECTION OF AQUEDUCT PUMPING MAIN

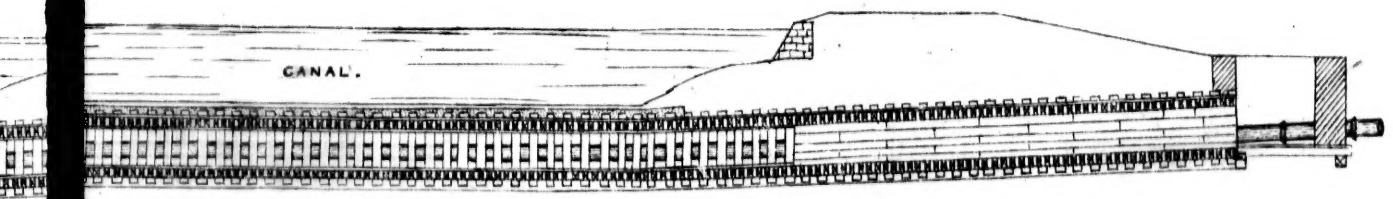
HORIZONTAL SCALE, FOR LONGITUDINAL SECTION.

200 feet

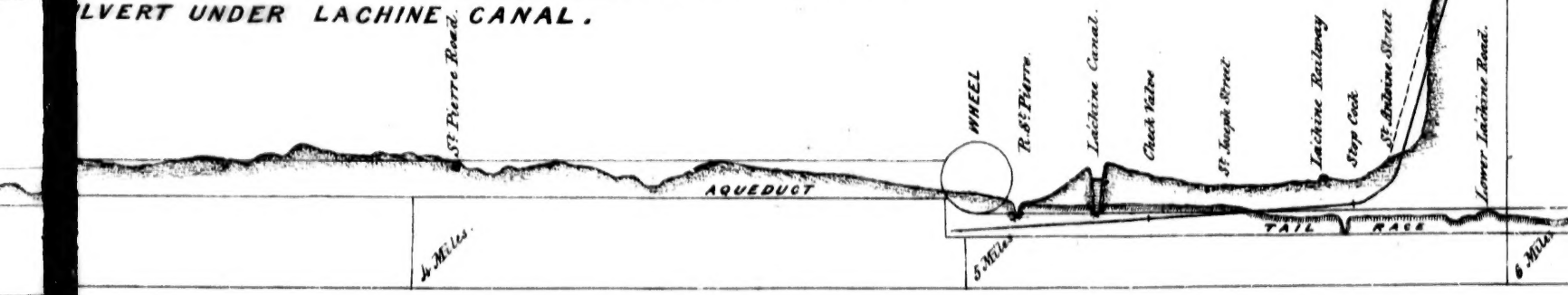
SECTION OF DISTRIBUTING RESERVOIR.



SECTION OF CULVERT.



LVERT UNDER LACHINE CANAL.

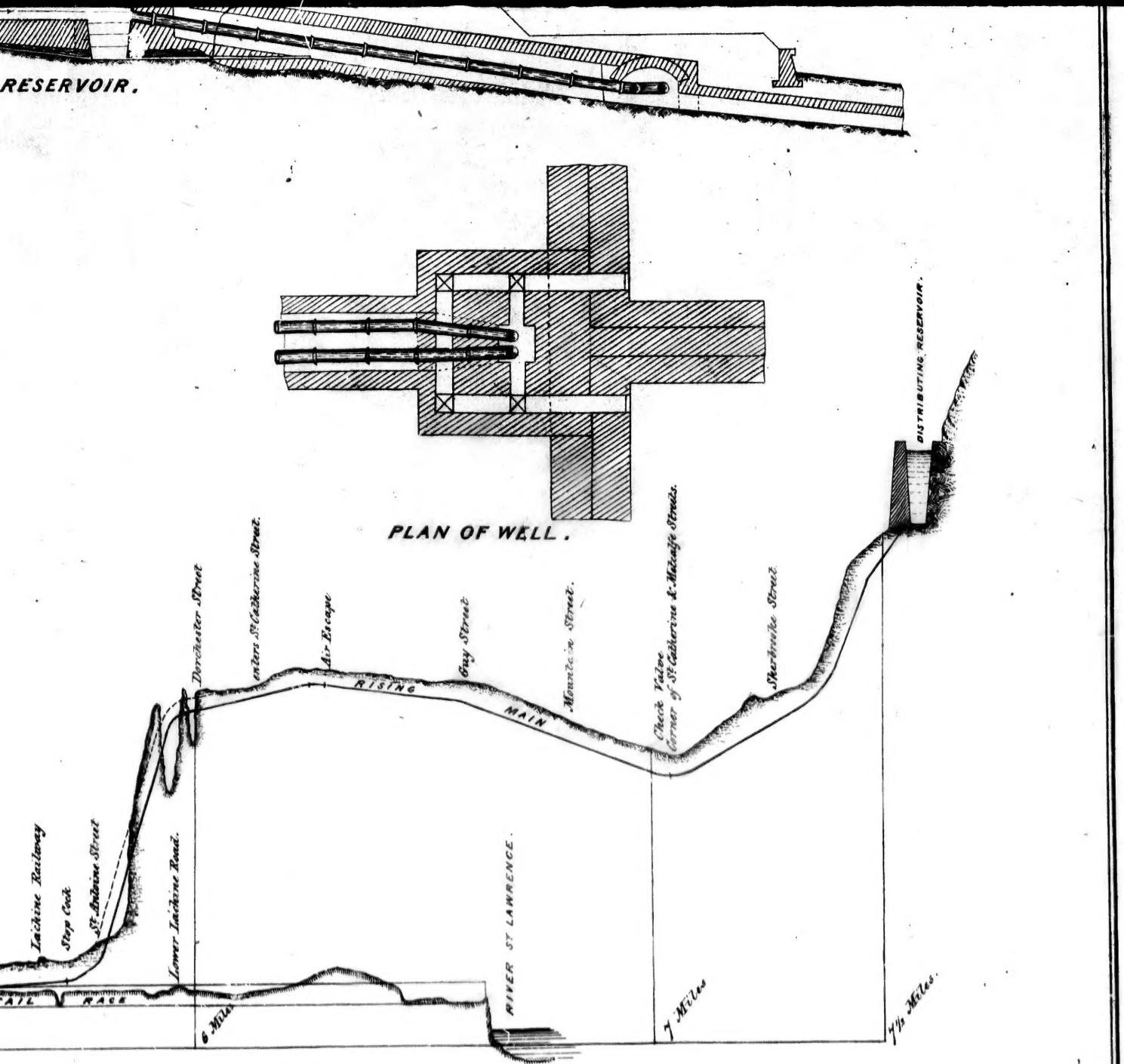


QUEDUCT PUMPING MAIN AND TAIL RACE.

VERTICAL SCALE

6000 feet.

0 5 9 10 20 30 40 50 60 70 80 90 100 110 120 130 feet.


RESERVOIR.
PLAN OF WELL.
DISTRIBUTING RESERVOIR.
Dorchester Street
enters St Catherine Street.
Air Escape
Guy Street
Mountain Street.
Check Valve
Corner of St Catherine & Mitcalfe Streets.
Sherbrooke Street.
RISING
MAIN
Lachine Railway
Stop Cock
St Antoine Street
Lower Lachine Road.
RIVER ST LAWRENCE.
TAIL
RACE
6 Miles
7 Miles
7½ Miles.